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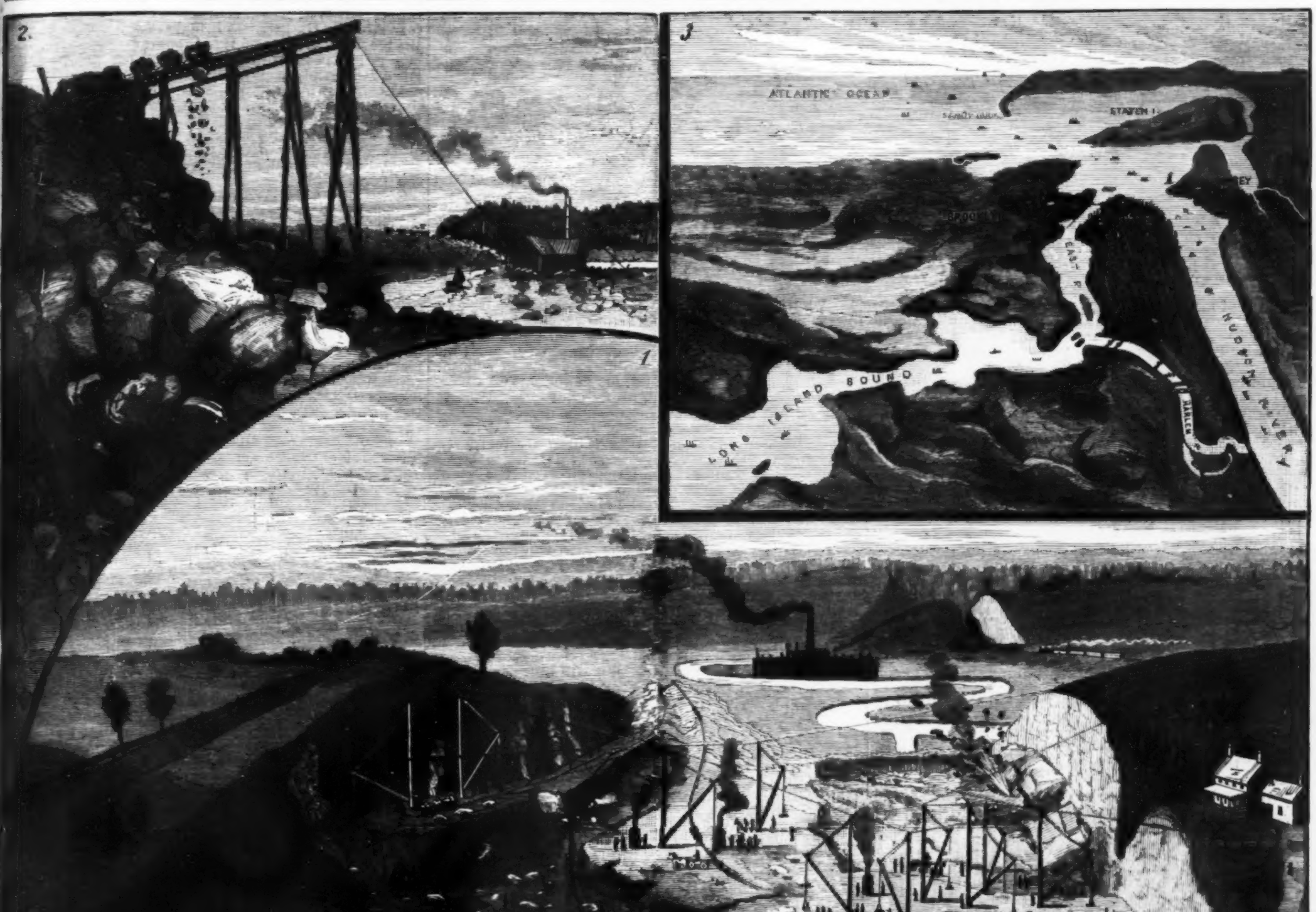


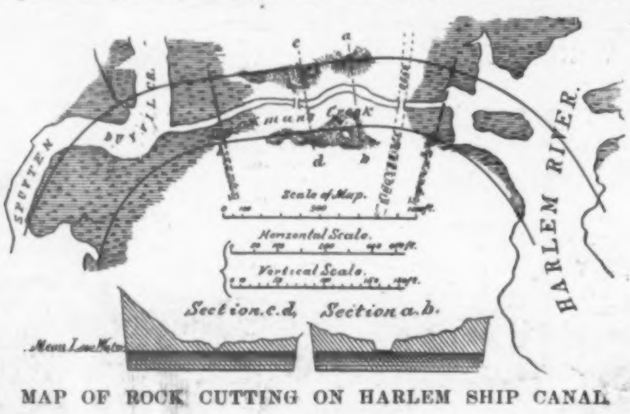
1. General view of the rock excavation and course of the canal. 2. Dumping rock and debris from trestle. 3. Bird's eye view of the connection between the Hudson River and Long Island Sound by the ship canal and Harlem River. 4. Dredging the channel in the Harlem River.

THE HARLEM RIVER SHIP CANAL.

THE HARLEM RIVER IMPROVEMENT AND SHIP CANAL.

The approaching celebration of the opening of the new ship canal at the northerly end of Manhattan Island, New York City, lends a new interest to this important enterprise. The work was executed in pursuance of what is known as the improvement of the Harlem River, New York, by the federal authorities under the direction of George L. Gillespie, Lieut.-Col., Corps of Engineers, U. S. A., chief engineer of the operations.

The history of the improvement extends over a number of years, beginning in 1873. The river and harbor act of March 3 of that year directed an examination to be made of Harlem River near the East River for the removal of rocks therefrom. Appropriations were made in successive years, and the examination of the Harlem, with certain improvements, was continued, until eventually it was decided that navigable connection should be made between the upper part of the Harlem and the Hudson River. The natural connection is by the water of Spuyten Duyvil Creek. This stream, which is very narrow and shallow in places, follows a crooked course and is available only for rowboats, except for a limited distance. Various ways were proposed of connecting the two rivers, but eventually, after due estimates of cost, the cut through what is known as Dyckman's Meadows, near Kings Bridge, a little above 200th Street, was determined on. Many legal difficulties were experienced and considerable trouble was had in obtaining the consent of the owners of adjacent properties. In some cases compromises were made, and eventually, in 1888, borings were made across the route to determine the character of the soil, and work shortly afterward began and is now in active progress.



MAP OF ROCK CUTTING ON HARLEM SHIP CANAL.

Our large cut shows the eastern end of the new canal. At this place the waters of Dyckman's Creek formerly ran across the island, connecting Spuyten Duyvil Creek with the Harlem. The last named creek can be seen in the cut a little to the right of the canal, winding in a circuitous course through the meadows and around Johnson's Iron Foundry, one of the well known landmarks of the locality. In the background can be seen the cut through which the New York Central Railroad passes, and a little to its left is the natural depression through which the waters of the creek penetrate. In the far background the Palisades, extending along the further or western banks of the Hudson River, are visible.

The small map shows the line of the portion of the canal the progress of whose construction is illustrated. It also shows the line formerly followed by Dyckman's Creek, now excavated out of existence. The hills of dolomite converging here had to be cut through, comprising practically all the rock cutting on the line. In order to pursue the work in comfort, two dams were constructed, one at each end of the proposed cut. Tongued and grooved sheet piling was driven across the axis of the canal, and by dumping solid earth and rocks back of the piling, its strength was still further increased. Then the excavation of the rock began. It was done by contract. The material was loosened by blasting, and as fast as broken up, hauled out on tramways toward the rear. The blasting agent was forcite, and steam drills were used for making the shot holes. The debris was hauled up on the railways to the dump, and deposited upon ground leased for the purpose. At the base of the hill an engine house was located, whence a cable was carried by which the cars were hauled up the steep incline. Eventually the material deposited on the dump will have to be removed, and it is unquestionable that much valuable building material can be procured therefrom.

The new channel is 18 feet deep at mean low water and varying from 350 to 400 feet wide. The law of May 20, 1879, provides that all bridges to be constructed over this channel shall be at right angles to its courses, and that the bridges at the draws shall not be less than 24 feet above high water of spring tide, and that no tunnel shall be constructed under it which will not permit the excavation of a 20 foot channel. Other restrictions are also imposed, applying to the Harlem River and canal. When the work is completed and the Harlem River channel adequately dredged out, a very important addition will have been made to the water front of the city. At present the Harlem River is practically limited for navigation to the point marked by the High Bridge. When dredged out, however, and completed to the Hudson River, a clear waterway will be provided for all vessels able to pass through the many draws and under the High Bridge. In transit from the North River to the Sound this route will cut off a distance of 10 or 12 miles. One of our illustrations shows in bird's eye view the new connecting link between Long Island Sound and the Hudson River which it will form when completed. Owing to the numerous bridges, however, the utility of this waterway as a through route will be limited to small sailing vessels, steamers, and barges. There is little doubt that for such traffic it will be very largely used, but the immense water front which will be developed by it, and the facilities it will provide for the delivery of coal and building materials to the upper part of the city, will be the most important features of the improvement.

A number of railroads cross the Harlem and Spuyten Duyvil Creek. Over the three railroad bridges at present existing four separate railroads send a large number of trains daily. The use of these bridges will of course be greatly interfered with if the draws have to be frequently opened. It is therefore seen that in the near future some change will have to be made in this respect.

Our thanks are due to Lieut.-Col. George L. Gillespie for facilities afforded by him. We have also to acknowledge the receipt of many courtesies from Mr. A. Doerflinger, the assistant engineer in charge of the work.

In connection with this subject we give a view of the new Speedway which is now being constructed along the margin of the Harlem River for the special benefit of owners of fast horses, as on this roadway they are allowed unlimited speed. The arches seen in the distance pertain to the High Bridge, which is built of masonry.

We also give a view of the Washington Bridge, which is built of steel. In the distance in this picture the High Bridge is also shown.

Not the least interesting features of the Speedway will be due to the public works and buildings along the river shore. The High Bridge is a representative of what was best in the civil engineering of the past generation. Its beautiful stone arches form an appropriate background in our large cut, appearing through the steel arch of the Washington Bridge, which structure is one of the greatest bridges of the world. At High Bridge and along the river's edge, to the south, is to be a public park, which will add to the prospect. At High Bridge proper there is a pumping station and reservoir, with buildings, all of which form impressive features of the scene; on the opposite bank of the Harlem is the Shipbuilders' Home, while on the New York side University Heights, with the new buildings of the University of the City of New York, may be ranked among some of the more striking elements of the scene.

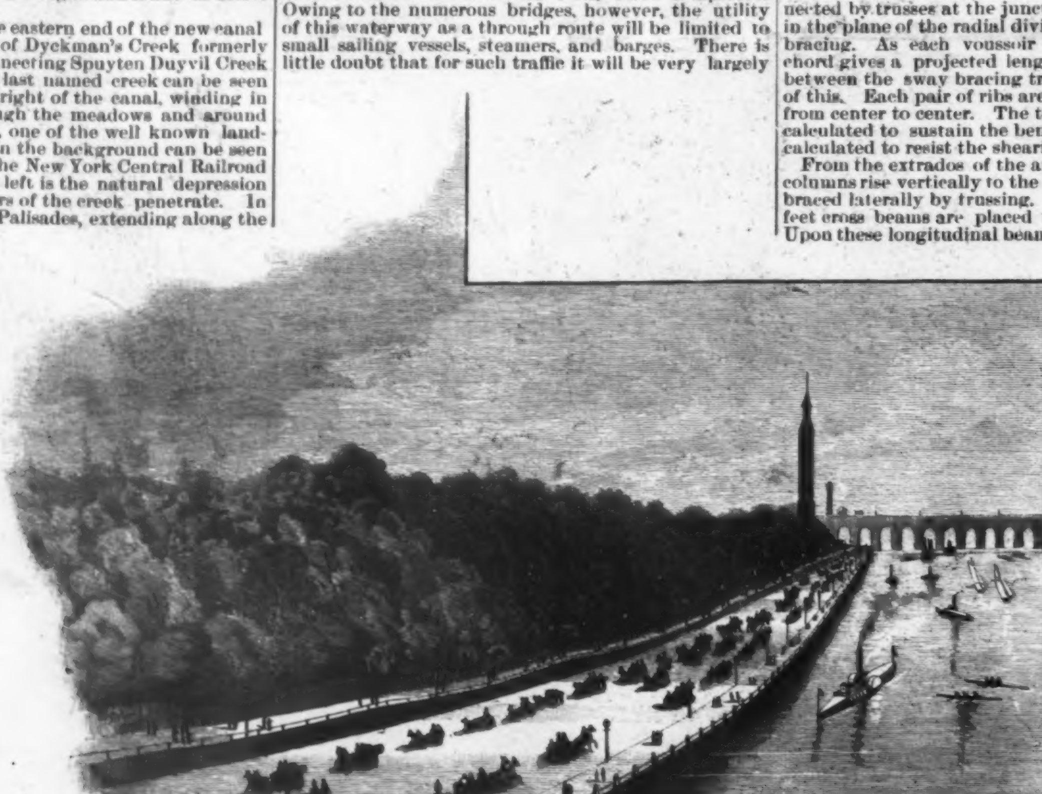
Concerning the Washington Bridge, we may say the masonry superstructure is of granite, and includes an east and west approach terminating in abutments from which the two great arches spring. The arches meet again at a central pier which acts as abutment for both, and which rises between them to the top of the bridge. The total length of the bridge and approaches is 2,380 feet; each approach is 660 feet long, leaving 1,060 feet for the main bridge. The western approach is level; the first portion, 260 feet in length, is in earthwork supported by masonry side walls. The rest is in masonry, including three semicircular arches, each of 60 feet span. The eastern approach starts on a lower grade, and for part of its length rises toward the bridge; 300 feet are in earthwork, as described for the other end. The remaining 360 feet includes three semicircular arches of 60 feet span and one seven-centered arch of 56 feet span. A clear width of 80 feet is afforded over this portion, as well as over the remainder of the structure, 50 feet of which are roadway, while 30 feet are devoted to the two sidewalks. The roadway is paved with asphalt.

The supporting members of the bridge proper consist of two steel arches of 510 feet span each and 90 feet versed sine. Each arch includes six parallel ribs 13 feet deep, divided by radial divisions so as to represent voussoirs. They are braced together horizontally to secure the whole against wind strains, and are connected by trusses at the junction of each voussoir lying in the plane of the radial divisions, so as to act as sway bracing. As each voussoir referred to a horizontal chord gives a projected length of 15 feet, the interval between the sway bracing trusses is a little in excess of this. Each pair of ribs are spaced 14½ feet laterally from center to center. The top and bottom chords are calculated to sustain the bending strains; the web is calculated to resist the shearing strain.

From the extrados of the arches thus formed, lattice columns rise vertically to the floor line. These are also braced laterally by trussing. At intervals of about 15 feet cross beams are placed to support the roadway. Upon these longitudinal beams are placed, the intervals between which are filled by arched buckle plates receiving the roadway.

The pivot system of skewbacks was used, and has already been illustrated in this paper.* As the arched trusses rise and fall under the effects of change of temperature or of load, the hinge joint works to and fro with theoretical exactness. The latter point has been determined by micrometric measurements.

As regards the load which the arches are constructed to carry, it includes 8,000 pounds live load per lineal foot of bridge. This is in addition to the dead weight



THE HARLEM RIVER SPEEDWAY, NEW YORK CITY.

* See Scientific American, February 18, 1888, page 101.

of the structure, which is about 33,000 pounds per lineal foot. A wind pressure of 1,200 pounds for the same unitary distance is allowed for. A 20 ton road roller can be taken over it without going outside of the very liberal factor of safety provided for in the table of unit strains.

The roadway is 151 feet above the river level. On the approaches it is bordered by a handsome stone parapet, with bronze ornaments. The bridge proper has an iron and bronze rail, designed by Messrs. Delinas & Cordes. Gas lamp posts and combined gas and electric light posts are placed on either side. Over the piers stone refuges with seats are placed.

Mr. William Hutton, of this city, was the chief engineer, assisted by Mr. Theodore Cooper.

MORTAR—HOW TO PREPARE IT.

By EDWARD WOLFF.

THE hardening of mortar—a mixture of sand, lime and water—is not merely a drying process, it is the result of the tendency of lime to take up carbonic acid gas from the atmospheric air which comes in contact with it. In the limestone from which the lime was obtained the lime was chemically or intimately united with carbonic acid gas in the proportion of 24 ounces of carbonic acid gas to 28 ounces of lime. This carbonic acid gas was by heating in the kiln driven out of the limestone.

In the slaking process water is added to the lime, and these combine chemically in the proportion of 28 ounces of lime to 8½ ounces of water to form a white powder. As this combination is going on rapidly a great amount of heat is developed. An excess of water will not chemically unite, but can only be mixed with the powder and no more heat is developed.

We have now the lime in a semi-liquid state and eager to unite again with carbonic acid gas in exchange for that part of water with which it is chemically united. The process goes on as soon and as long as carbonic acid gas is supplied and until lime and carbonic acid gas are again combined in the same proportion in which they were combined in the limestone. During this chemical process little crystals are forming which assume positions in relation to each other into which attraction forces them. In these positions they will be as near to each other as possible and the attraction will be powerful.

If after the chemical and crystallizing process has advanced disturbance is made, so that the particles or crystals are forced out of their naturally assumed positions, they will not be able to rearrange themselves, and cohesiveness will be lost. First, flat surfaces will have been in contact; after the disturbance, corners or edges will rest against flat surfaces, or edges will cross edges, which means increase of distance and corresponding decrease of attraction. Mortar which has suffered such disturbance, or mortar which had been exposed to the air long before it was used or deposited in its permanent place, will never form a good binding material.

Lime obtained from marble slakes readily, and assumes a uniform semi-liquid consistency as soon as the required amount of water is added, but with lime obtained from other limestones the slaking process is slower, or not uniform, and at least two weeks should be allowed for the impure parts or particles to slake before sand is added, or the mortar prepared for use, and during this time access of air is not required and should not be invited or made possible.

The slaking operation should be done in a watertight box made of boards, and so much should be mixed in that the contents will never get dry and a sheet of water will remain on top to prevent access of air. If the box will not hold the entire quantity of lime required, the contents may be emptied into a cavity made in the ground close to the pan, and this process may be repeated, and it should be done at least two weeks before sand is added, or before the mortar is prepared for use. Slaked lime prepared and kept as stated has been found free of carbonic acid after many years, air and gas having not been able to find access.

Instead of following the procedure in slaking lime as recommended above, we see in this country, or at least in the neighborhood of New York, a faulty process adopted, which consists in loosely mixing the sand to the slaking lime immediately after water has been added, and forming a dry heap on the surface of the ground which is left lying there several weeks to give time for complete slaking before the sand is worked in evenly and the mortar is considered ready for use.

This heap arrangement is the most perfect arrangement for circulating air through a material which should be guarded against contact with air. The sun heats the surface of it, makes the air escape after it gives up its share of carbonic acid gas, while at the base of the heap and at the shady side, a fresh supply enters to fill up the vacuum after having circulated through the heap and it has been robbed of its share of carbonic acid gas. That this procedure really happens in such a heap we can easily see when in a wineglass, for instance, we place a lump of freshly slaked lime and in another glass a small quantity of material taken from a heap such as described above, and which has been prepared a few days before; fill both glasses nearly up with water and add a few drops of muriatic or sulphuric acid to each. In the first glass nothing can be observed, while in the second glass we will see in the shape of small bubbles the carbonic acid escape, which has been absorbed by the lime from the atmospheric air circulating in the heap.

That this process of preparing mortar for use is faulty, that by this process we cannot get a good binding material, we can frequently see in this city and neighborhood when an old brick wall built with such mortar is being broken down or collapses, the bricks coming down clean and the mortar in the shape of dust.

It is not probable that this mortar has been prepared with the object in view that, after fifty or sixty years' service, the bricks should be in condition to be used over again without the trouble of clearing them of adhering mortar; much more likely the want of knowledge of the natural laws involved was the cause.

The mistake, in brief, frequently made in preparing mortar, consists in mixing the imperfectly slaked lime loosely and dry with the sand, and in this state giving the impure particles of lime the time to slake.

The use of sand, which is mixed with earthy matter, even the use of spring water, which has much carbonic acid gas dissolved in it, in preparing mortar, lessens its quality of binding material; a faulty process in preparing it should not be added.

Annexed are rules under which the government of Wurtemburg, Germany, accepts mason work, and which certainly deserve consideration:

The contractor has to take care that in preparing mortar under all circumstances quartz sand of good quality, sharp and pure, will be used. Good lime is in the ordinary way to be slaked in water at least fourteen days before the mortar is required for use, to give time for its transformation into a uniform mud. The lime pan and sand heap have to be covered—mark separately. In preparing the mortar with pure lime, three parts of sand per volume are to be taken with one part of the slaked lime, and all is to be worked together into a perfectly even mixture. In preparing the mortar with less pure lime, sand and lime are to be taken in equal parts with the use of as little water as possible. Very particular care should be taken that a greater supply of mortar will never be prepared than can be used the same day, since under no circumstances should mortar be used that has been prepared the day previous.

Portland cement (hydraulic mortar) being a different material hardens under different conditions; it hardens under water without access of air or carbonic acid gas, and also, though not as well, when exposed to the air; as soon as water has been added or mixed in, all the conditions for the hardening process are collected. The hardening process of cement, as well

WASHINGTON BRIDGE, NEW YORK CITY, LOOKING SOUTH.

as that of mortar, should go on after they have been applied and not before, but as Portland cement hardens rapidly, the rule not to mix it faster than it is needed for use is generally observed.

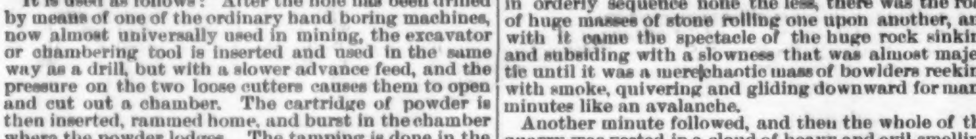
It is not intended here to explain the chemical actions which cause the hardening of hydraulic mortar or Portland cement, but it may be stated that in ordinary mortar it is not expected that any chemical action between the sand and lime takes place. If traces of silicate of lime have been found in mortar, the silica probably was present as impurities in the limestone.

It is a matter of fact, that lime mixed with pure sand gives much better results than lime not mixed with sand, and it is supposed that the sand merely serves as a skeleton to make the mixture porous enough to readily allow the water to escape and air to penetrate while the hardening process is going on. —The Engineer.

EXCAVATOR FOR BLASTING COAL AND TUNNELING.

IN blasting coal and rock the explosive should be so placed that its full force may be expended in forcing out the greatest amount of material possible. To effect this result it is often difficult, and sometimes impossible, to drill the shot hole in the right position. This difficulty occurs in blasting coal, and in driving tunnels, where the holes drilled are mostly breast holes. To overcome this difficulty and enable all the explosive to be got behind its work, the patent excavator or chambering tool has been designed, and its value for breast holes in tunneling and in blasting coal will be evident to those accustomed to this work.

It is used as follows: After the hole has been drilled by means of one of the ordinary hand boring machines, now almost universally used in mining, the excavator or chambering tool is inserted and used in the same way as a drill, but with a slower advance feed, and the pressure on the two loose cutters causes them to open and cut out a chamber. The cartridge of powder is then inserted, rammed home, and burst in the chamber where the powder lodges. The tamping is done in the usual way. It will be seen that this chamber enables all the powder to be put behind the material to be blown out, and also offers the largest area for the gases of the powder to act upon in a direction at right angles to the direction in which the hole is drilled, as well as a large surface in a line with the hole. From trials made in blasting coal with this system it has been found that from two to four times more coal can be dislodged by the same quantity of powder employed in an ordinary hole in a breast shot. The hole is drilled as deep as the coal is holed, and the full force of the blast acts at the back and spreads for a long way



EXCAVATOR BLASTING AUGER.

parallel to the face of the coal, thus pushing it off toward the face. The Hardy Patent Pick Company, Sheffield, are the makers.—The Engineer.

THE FALL OF TALCEN MAWR.

UNTIL the afternoon of April 27, Y Talcen Mawr was the central point, and perhaps the most striking feature, of those famous quarries near Bethesda which have been in operation since the reign of Queen Elizabeth, and have changed half the rugged protuberance of the mountain called Bronllwyd into a deep amphitheater. Many thousands of people who have visited the quarries must carry with them a memory of the Talcen. It was a rough slab-sided obelisk of gray rock with a bold vein of white quartz at the summit. Its height from the bottom of the quarry was about 300 feet, and it was pierced at regular intervals with tunnels representing the level of operations at various periods in the past history of the quarry.

At all times this great pillar of green rock presented a picturesque appearance, whether it was viewed from above or below, for the terraces, which the quarrymen call galleries, of purple slate, rising tier upon tier, one upon another, almost to the top of the mountain, formed a singularly effective background. Opinions vary as to the reason why this upstanding fragment of a dike which ran across the center of the quarry, from north to south, was suffered to remain, while the dike itself was cut away on either side; but the better opinion is that a manager of the quarry who flourished at the beginning of the century, not foreseeing the colossal scale upon which the quarry would be worked in the future, hoped that this portion of the green rock might serve as a support for one side of the quarry. But the quarry grew beyond his expectations. The quarrymen cut through the dike on either side, and left the Talcen in obelisk, which grew more and more picturesque and more and more dangerous every day and every year as the slate rock was cut away deeper and deeper at its base.

It was in August of 1894 that, after a report from Mr. E. A. Young, the chief agent, had caused Lord Penrhyn to make a personal inspection, the Talcen was doomed, and the wisdom of the sentence was proved almost at once by the sudden fall, fortunately in the night, of a fragment weighing several tons, which, if it had fallen in the day, must have destroyed a large number of quarrymen. From that date till April 27 preparations for the great blast proceeded, and on that day the huge pillar, weighing 125,000 tons at the least, was demolished. The spectacle was imposing in the extreme.

On the very brow of the quarry, fully five hundred yards away from the scene of the coming explosion, and some hundreds of feet above it, a knot of privileged spectators was assembled near a flagstaff. Among them were Lord Penrhyn, Lady Falmouth, the Hon. Henry Mostyn and the Hon. Mrs. Mostyn, the Hon. Misses Pennant, the Hon. Frederick Wynn, of Glynllifon, the Hon. Charles Wynn, of Rug, and Mrs. Wynn, Colonel the Hon. W. E. Sackville West, and Miss Cecilie Sackville West, the Hon. W. W. Vivian and others. The time was a few minutes past three. All along the brow of the quarry, and up on the slopes of the mountain above, were crowds of spectators. All knew that in the bowels of the Talcen were two charges of powder, one of three tons and the other of four tons.

At last the decisive moment came. The flag on the brow of the quarry was hoisted by the Hon. Miss Pennant. A blue wisp of smoke rose from the base of the pillar, and all present knew that the triplicate fuses furnished by Messrs. Bickford Smith & Company had been lighted by Mr. Pritchard, and that the huge bricked up chambers of powder specially manufactured by the Elterwater Company, and used rather than gelatine by reason of its gradual action, would do its work shortly. There was a silence of expectation for five minutes or so, an interval which was almost painful; but still the wisp of blue smoke rose lazily, and a little cascade of water on the Bethesda side of the rock fell down merrily. The minutes passed very slowly, but at last—sixteen minutes and a half after the flag had been hoisted — there was a crashing sound.

The noise was not so loud as one would have expected. With it came an outburst from the base of the pillar of smoke of minute dust and of something that was either flame or red hot powder of stone. Away from the top of the pillar sped two kestrel hawks which have nested there for many a year. The base of the great rock seemed to fall away as water falls from a fountain jet at its highest point. There was no sign of any stone being thrown to a great distance. Then in less time than these words occupy in the writing, but in orderly sequence none the less, there was the roar of huge masses of stone rolling one upon another, and with it came the spectacle of the huge rock sinking and subsiding with a slowness that was almost majestic until it was a merechaotic mass of bowlders reeking with smoke, quivering and gliding downward for many minutes like an avalanche.

Another minute followed, and then the whole of the quarry was vested in a cloud of heavy and evil smelling smoke, of which, however, the keen wind made short work. So the great rock upon which the Prince of Wales looked last year, when it was the salient point of the quarry, was annihilated. Later inspection by Lord Penrhyn and all his party showed that the enterprise, which reflects great credit upon Mr. Young, had been entirely successful.—London Times.

JAPANESE SHIPPING.

DR. FRANCIS ELGAR read a paper recently before the Japan Society of London, upon "Japanese Shipping." Engineering, in making abstracts therefrom, says: It has naturally excited great interest, as it describes the growth of Japan's naval power, and shows what that power is and what it is likely to become in a very striking manner. We are convinced that few who are not personally acquainted with Japan and the Japanese were prepared to hear such an account of the maritime progress of that interesting nation as Dr. Elgar gives. It must be surprising to many to learn that steel shipbuilding and marine engineering are already established industries in Japan: and that the time may not be so very far distant when, instead of being a good customer for warships and mercantile steamers built in England, Japan may not only build all she requires for herself, but become one of our competitors in the shipbuilding trade. The progress that has been made in this direction during the last quarter of a century is truly marvelous. Dr. Elgar says that about 250 years ago "it was forbidden to build in Japan vessels above a certain size that would be large enough for long sea voyages. The size was limited to 500 koku, or about 76 tons measurement, and a vessel was not allowed to have more than one mast." A fatal blow was thus given to the foreign trade and the shipping of Japan. The Japanese minister, Mr. Kato, remarked, at the close of the discussion, that the rulers of the country at that period "were by no means aware of the far-reaching consequences of the step they took in prohibiting the construction of ships beyond a certain size. As soon as the prohibition was put into operation, the enterprising spirit of the Japanese with regard to foreign commerce, which till then had been rapidly coming to the front, gradually dwindled away, until at last the people almost forgot the existence of nations and peoples outside the confines of their own borders. They were awakened from this state of existence about forty years ago by a foreign expedition which compelled them to open some of their ports to commerce, and when they awoke they discovered to their surprise and dismay that there were many nations in the world besides their own, and that many of them were more powerful and more civilized than Japan. Ever since that time, and especially since the restoration of the imperial power to its proper place, twenty-eight years ago, the whole nation, from the emperor downward, had resolved that they must do everything in their power to make up for the neglect of the past, and fortify themselves for taking part in the race of the world, and they had acted on that resolution."

Dr. Elgar shows that the Japanese have acted to some purpose in the manner described by the minister in his eloquent and interesting speech. Several small wooden men-of-war were procured by some of the feudal princes after the "awakening" referred to by the Japanese minister about forty years ago; but little real progress was made till about twenty-five years ago. This has resulted in the creation of a navy comprising thirty-three ships of all classes, among which are an armorclad, the Fuso; three cruisers, with small belts of armor at the water line; seven fast steel cruisers of modern construction, protected by deck armor; six steel unprotected cruisers; and one torpedo gunboat of modern type. One of the cruisers, the Yoshino, is perhaps the fastest in the world, as she is reported to have reached a speed of twenty-three knots on trial. Four of the other protected cruisers have trial speeds of eighteen and three-fourths and nineteen knots and the remaining three a speed of sixteen knots. Two of the nineteen knot cruisers were built in Japan, in the naval yard at Yokosuka. Two more steel cruisers of an improved type, to have a speed of twenty knots, are being built and engined at the same yard, and a third is in progress in the new naval yard at Kure, near Hiroshima, in the Inland Sea. Two large battle ships are being built in this country, one at the Thames Iron Works and one at Elswick. The Japanese also possess forty torpedo boats, sixteen of which were built in Japan.

This navy is now increased by twelve vessels taken from the Chinese, which include the armorclads Chen-Yuen and Tsi-Yuen, the coast defense armorclad Ping Yuen, the deck-protected cruiser Kwang Ting, and six gunboats of the Alpha Beta class. As Dr. Elgar says, when the vessels now building are completed, and the Chinese ships are repaired, the Japanese navy will be one of great power. Not only so, but it contains all the elements of development and progress. The Japanese "have acquired with the ships the ideas and knowledge which are necessary to understand them in all the details of their construction and use, to enable them to produce such ships for themselves, and to train officers and men who can use them effectively in action. It is one of the most striking instances in the history of the world of the acquisition and assimilation of knowledge that we would have thought in Europe were foreign to the genius of the people." Dr. Elgar praises highly the officers of the Japanese navy, who have raised the modern naval service of Japan to a high state of efficiency. He says: "Many reasons have been given for the success of the Japanese navy against the powerful ships of the Chinese, but these have chiefly related to the construction, the armaments or the speed of the ships. Speaking as a naval constructor, and one acquainted with the principal ships on both sides that fought the battle of the Yalu, I should say that the battle was won by the good organization, discipline, training, and bravery of the Japanese seamen, and the knowledge, skill, and determination of the commander and officers. It was a struggle between a highly organized and efficient naval service on the one hand and a very inferior one on the other; and the difference in the manner in which the ships were handled and fought appears to have been sufficient to override all considerations of the relative qualites of the armaments or of the ships themselves. I should think it very probable that if the Japanese had had the Chinese fleet and the Chinese the Japanese fleet, the ultimate result would have been the same."

Dr. Elgar also gives a very interesting account of the rise of the modern Japanese mercantile marine after the expedition to Formosa in 1874, and of its present position; and here again is much matter for wonder and for reflection. It appears that on October 1 last, the Nipon Yusen Kaisha (Japan Mail Steamship Company) owned sixty vessels, with an aggregate net tonnage of 60,500. This company has regular lines to Shanghai, Corea, the northern Chinese ports, and Bombay; and to Vladivostock in summer. It also sends occasional steamers to Hong-Kong, Honolulu, and Australia. There are two other steamship companies that trade to Chinese and Corean ports. The coasting trade of Japan and the trade between the various islands is carried on entirely by Japanese vessels. In 1892 there were 131 shipping companies in Japan owning vessels of European type. These companies then possessed 643 steamers of 102,322 tons, and 778 sailing vessels of 45,994 tons, and the number and size of these increase greatly every year. There were also in 1892 as many as fifty-three shipyards employed in building vessels of European type, which included forty-four steamers. Most of these vessels were very small, but the facilities for work and the demand for larger steamers are rapidly increasing.

Dr. Elgar stated he has heard that steamships of moderate size can now be built in Japan at much less than the price for which they could be built and delivered in an English port. This strange sign of the times was afterward confirmed by Mr. Martell. There seem to be good grounds for believing that Japan will become a great shipbuilding country. Dr. Elgar says "the Japanese are highly qualified for, and are very successful at all the work which is required on the construction of a modern ship and her machinery. In saying this, I am able to speak from experience, as it was my duty to watch the matter closely in Japan for nearly a year and a half, and to report to the government upon any improvements that might be required in the working of the naval yard at Yokosuka about fourteen years ago. In all the various branches of shipbuilding and marine engineering, the Japanese mechanic is excellent. He is as intelligent as the best European mechanics, at least as careful in his work, and I am inclined to think he is quicker in perception and has a lighter touch. The Japanese are more subject to discipline, and are most industrious and painstaking. Labor difficulties, that are so common here, are unknown there. Wages are very low, and are, of course, paid in silver or its equivalent, and I do not know of any inferiority or inefficiency on the part of the Japanese mechanic."

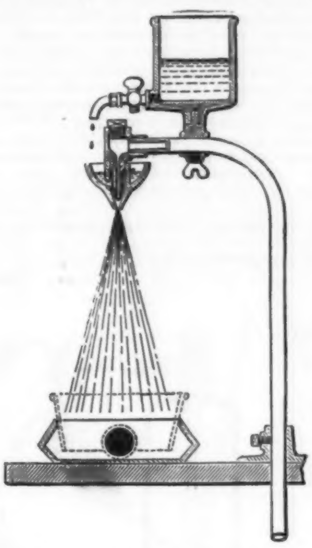
Dr. Elgar has done good service in putting forward so prominently the useful information contained in his paper. It includes, besides the points already mentioned, an interesting description of the construction and equipment of the ancient galleys and trading junks of the Japanese. It is only fair to Japan that we should realize her strength and her real position as one of the civilized and important powers of the world; and it is an advantage to us to know what we have to deal with in the extreme East in the way of sea power and trade competition, which are now becoming so formidable. The Japanese minister assures us that the object of the Japanese government has always been peace and the peaceful development of their country, and he hopes that the endeavors of his country will receive the cordial sympathy of the English nation. Dr. Elgar says the chief interest which Japan has is that of peace, and of being left free to develop her native

industries and foreign trade, and to improve the condition of her people, and in this, he points out, we have a guarantee that the growing influence of Japan in the East will not be dangerous to the cause of peace in the world.

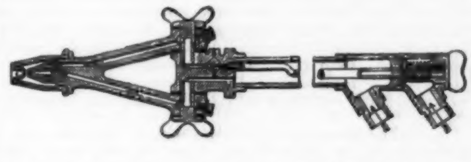
We accept these assurances of the aims and objects of Japan, and welcome her into the arena of free and open trade competition—a competition which we do not doubt will in the long run be for the benefit of the world, and for our own advantage as well as that of the Japanese. It was characteristic of modern Japan, and illustrative of much which has been achieved by it, that the Japanese minister should declare his intention at the close of the meeting to send Dr. Elgar's paper for publication to the magazine of the Society of Maritime Affairs in Japan.

PAINTING MACHINERY.

It is perhaps surprising that long before this the tedious and laborious process of painting by hand, especially where large surfaces have to be covered, should not have been successfully superseded by me-



chanical appliances. Experiments in this direction were, it is true, made during the construction of the Chicago Exhibition buildings by means of a specially designed sprayer, and the paint was laid on in this manner in place of hand work by brush. Hitherto the machinery and power required for spraying paint in this manner have been considerable. Messrs. A. C. Wells & Company, of London and Manchester, after a long period experimenting made in conjunction with Messrs. Henry Wallwork & Company, of Manchester, have, however, perfected various appliances for spraying paint by means of compressed air, in which they claim to have overcome the many practical difficulties previously attendant on the spraying of heavy paints, tars, etc., and to have produced a simple apparatus working with small power. We had an opportunity of inspecting these various appliances and witnessing experiments with them at the works of Messrs. Wallwork & Company the other day, and the results obtained were most satisfactory. The paint is atomized and sprayed on to the work by a stream of compressed air, and we illustrate the apparatus by which it is done. In most engineering works where high rate of speed in painting is wanted, as, for instance, in boiler and girder shops, a supply of compressed air may be got from the pneumatic mains, but where this is not available, a compressor is supplied, as shown in Fig. 1. This may be worked by power, or, for certain classes of work where only small pressure is required, by hand. It is fitted with gage and a safety valve to protect the hose from any excess of pressure, and the hollow column serves as an air reservoir. The single acting pump is of simple construction, the plunger being fitted with a lifting cup leather, which combines the functions of packing and inlet valve, and is kept cool by the passage of fresh air past it at every stroke. From the compressor the air is led through flexible hose to the paint tank or container, shown (Fig. 1) in part section. This is fitted with an airtight cover and clamping screws, the paint being contained in a paint pot, readily removed and replaced by another when a different color is required. This arrangement of interchangeable tins is also important, as facilitating easy cleaning. The container is furnished with a semirotary stirrer (the blades of which are shown dotted in our illustration), the spindle passing through a stuffing box in the cover and ending in a handle whereby the whole thing complete may be carried about. The compressor is necessarily fixed or stationary, but the



paint tank connected to it by the single air hose can be moved close to the work, while the length of hose from the tank to the nozzle gives the freedom of movement necessary. Air pressure is admitted to the tank by the bottom valve, and forces the paint up an internal pipe and along a hose from the tank top to the spraying nozzle, to which air pressure is also led by a second hose, as shown. The nozzle is practically an injector of special form, and the determination of the best form has been a subject of prolonged experiment. The flow of paint at the nozzle is controlled by a small plug valve and spring lever on which the operator keeps his thumb while working, and which on release closes automatically. Much difficulty has always been experienced from the tendency of small way valves of this class to become choked by particles or pieces of skin, or silted up paint sediment. Messrs. Wallwork and Wells overcome this by an ingenious arrangement, whereby the nozzle with a further movement of the spring lever is reversed and directly connected with the air pressure, and the obstruction blown out. When it is required to change from one color of paint to another, or to use a different material, such as varnish, the can previously in use is removed, and the air or, if necessary, paraffin oil blown through the length of hose which supplies the paint, until it is completely clean, which is readily effected in a very short space of time.

These painting machines are made in various sizes; the working capacity of the one we saw working was about three square yards per minute. A 30 foot by 8 foot boiler can be covered in less than an hour, and at one large bridge yard, where the apparatus is in constant and successful use, a plate girder 70 feet by 6 feet by 2 feet, with gussets, verticals, etc., was coated with boiled oil by one nozzle in two hours, or more than equal to a full day's work for a man with a brush. A further advantage claimed is that cheap common paint, of which two coats are necessary, if put on with a brush, can be laid on so perfectly by the spray that a single coat is ample. Should a second coat be advisable, it can be put on without waiting for the paint to dry, and the saving of time from this fact alone is very great. For better class joinery and cabinet work the machine has the merit of producing a perfectly smooth surface, which, being free from brush marks, does not require rubbing down and repeated coats to bring it to a face. For painting small articles at the bench, Messrs. Wells supply the apparatus shown in Fig. 2. The paint is held in the upper container, and drops by gravity into the small cup, whence it is sprayed downward on to the article by compressed air supplied from any convenient source. The dish below may be connected to an exhauster, so that any superfluous spray is drawn off to be used again. For decorative or relief work the spray is admirably adapted, since it penetrates to the most minute recesses, which could only be reached clumsily and slowly by a brush, and covers the whole surface evenly, rapidly and smoothly without either blunting the outlines or unduly filling in the depressions, and we were shown a number of specimens of Lincrusta Walton which had been most efficiently painted in various colors, and afterward with the same appliances elegantly tinted in other shades or in bronze, by simply applying the sprayer at an angle so as to catch one surface of the projecting patterns.

In Fig. 3 is shown a long-handled nozzle for overhead or underfoot work. The air is carried through the thin outer steel tube, while the paint passes up the small internal pipe. The whole is very light and compact, and is intended to take the place of the "Turk's head" used in ship and boiler yards. The usual paint and air pipes are coupled on to the lower end, and a swiveling movement of the nozzle head allows of alteration in the angle of direction of the spray.

A further development of this sprayer is a very ingenious arrangement which should render the appliance specially useful to artists and decorators. This consists of a modification on a small scale of the larger apparatus, so that it can be readily held in the hand. It is made in several forms, the one we saw being cylindrical, the top arranged as the spraying nozzle, and in the cylinder proper were four receptacles for paint or color. These could be readily charged or recharged, and were connected to the spraying nozzle and arranged with valves in such a way that any of the four colors could be sprayed as desired, or any two combined to produce a distinct color, and we saw some very pretty effects produced by this arrangement.—The Engineer.

PAINT SPRAYING MACHINE.

BANANA MEAL AND ITS FUTURE PROSPECTS.

A good deal of attention has been drawn of late to the use of the banana as a source of flour or meal, and though such an application is by no means new, or the discovery modern, it seems not at all unlikely that banana flour is an article that has a prospect of a great development in the near future. Wherever the banana or plantain thrive, the fruits, when dry, are converted into meal, and used for making cakes, puddings and for various other uses in cookery. This has been very fully treated of in the Kew Bulletin for August, 1894, where a recent analysis by Professor Church is given.

Attention is also drawn to the following extract from a report on the exhibits sent from Jamaica to the Chicago exhibition in 1893:

"The banana meal engaged the careful attention of several of the leading grocers in Chicago and elsewhere. One large house in Chicago—Sprague, Warner & Company—after testing samples of this meal, was so pleased with the result that it offered to undertake to introduce it as a food for infants and invalids, provided the producers would guarantee to supply the necessary amount to advertise it extensively in the United States. Messrs. Sprague, Warner & Company estimated that a sum of not less than $25,000 would be necessary to launch this new product on the American market, and unless this sum were forthcoming they did not see their way to dealing with it, on the ground that no sales in any quantity could be expected. The proposal was in due course submitted to the exhibitors whose meal had been experimented upon; but unfortunately those gentlemen were unable at the time to adopt the course proposed, and the matter is still in abeyance."

The commissioner closes this report by saying: "I am strongly of the opinion that with a judicious outlay of capital, and with a reasonable certainty that no sudden changes will be made in tariff regulations, there is a market open for banana meal in the United States."

Since the date of this report it has been proposed to establish a factory for the preparation of the meal in Jamaica, which it is estimated could be made remunerative if a supply of the small bunches of bananas could be obtained at the rate of 7d. per 100 pounds, including the stalk. The director of public gardens in Jamaica, however, after communicating with several planters, found that the general opinion was that the price mentioned would not pay them to supply their small and unsalable bunches at the above rate, so that the question of the manufacture of banana meal on a large scale in Jamaica seems at present in abeyance.

Some notes on the use of banana meal in brewing are given in the Bulletin of the botanical department of Jamaica, for July last, which run as follows:

Mr. Kahlke, one of the best known manufacturers of yeast in Germany, writes in this connection: "Banana flour, without doubt, from its richness in starch and its good flavor, is particularly suitable for the manufacture of yeast. This flour is easily rendered saccharine. The yeast obtained by adding banana flour to the other ingredients has a good color, all the requisite properties of an excellent class of yeast, and moreover keeps well. The alcohol obtained from it leaves nothing to be desired, so that this flour may be introduced as an article of commerce, and employed without any special preparation. Satisfactory experiments have also been made in some breweries, where 20 per cent. of malt has been replaced by the flakes and flour of bananas. The flavor of beer was not altered, and the quantity of liquid was increased, and the malt was replaced by a less expensive substance. Experiments are being made in which the proportion of banana flour is increased."

One of the great Belgium brewers writes: "These flakes are macerated in the vat with the malt, and the result was much superior to that of maize, the drainage of the mixture was a little difficult at first, but after being stirred a second time the draining proceeded rapidly. Briefly, the use of the flakes may be

considered both advantageous and easy in brewing." Different banana flours, and notably that prepared specially for the manufacture of glucose, have been tried in some glucoseries. Although difficulties were met with in the manufacture, principally with respect to discoloration, it has been shown that the glucose obtained from it has a good flavor, is very sweet and slightly aromatic.

It is highly probable that a special study of the subject will surmount the slight difficulties which at first presented themselves in the use of this new product in glucoseries. Very nourishing bread has been made from equal proportions of bananas and wheat and rye flour, and even from a mixture of two-thirds of banana and one-third of ordinary flour. A sweet banana flour, having an agreeable flavor of the fresh fruit, appears to be specially suitable for cakes and biscuits.

THE CARBIDES AND ACETYLENE COMMERCIALLY CONSIDERED.*

By T. L. WILLSON and J. J. SUCKERT, Ph.D.

BEFORE entering upon the subject matter of this paper, namely, the commercial consideration of the carbides and acetylene, we believe that a brief history of these compounds, their methods of formation and their chemical and physical properties, will be of interest to you. That carbon will combine directly with various metals under the influence of heat has long been known to chemists, but these compounds, generally known as "carbides," have been but imperfectly studied, and, with the exception, perhaps, of the carbides of iron, are hardly known.

The only group of carbides which interests us this evening is that of the carbides of the alkali and alkaline earth metals, such as the potassium, sodium, barium, strontium, and calcium carbides; for the reason that these are the only carbides which, when brought into contact with water, will decompose it; forming generally the hydrated oxide of the metal and acetylene gas. Of these latter carbides, the combination of calcium with carbon has the greatest commercial possibilities, on account of the low first cost of the raw materials which enter into this combination, namely, lime and coal, the abundant deposits of the same in all quarters of the globe, and the commercial value represented by the by-product, hydrate of lime, which is obtained in large quantities by the decomposition of the calcium carbide with water.

The history of the discovery and methods of production of this group of carbides may briefly be stated as follows:

The first authentic reference to this subject was the discovery by Sir Humphry Davy that carbon and potassium, when heated to a temperature sufficiently high to vaporize the potassium, formed a compound which, after cooling, would effervesce with water.

Berzelius, in 1836, determined that the black substance formed in small quantities as a by-product in producing potassium from potassic carbonate and carbon was carbide of potassium.

Woehler, in 1862, prepared calcium carbide by fusing an alloy of zinc and calcium with carbon, and ascertained that it decomposed by contact with water, forming calcic hydrate and acetylene.

Berthelot, in 1866, described sodium carbide or acetylene sodium. He produced it by the following method: Metallic sodium, when slightly heated in acetylene gas, puffs up and absorbs acetylene with the formation of the compound C_2HNa. At a dull red heat sodium destroys acetylene, forming a black carbonaceous mass, C_2Na_2. The reaction is expressed by the following formula:

$$(C_2H_2 + Na_2 = C_2Na_2 + H_2).$$

This compound, C_2Na_2, in contact with water, regenerates acetylene.

From 1866 until 1888, a period of twenty-two years, nothing further has been recorded of scientific work done in this direction; as a matter of fact, the compounds so produced were not only very impure, but their cost of production also was so great as to render their commercial use prohibitory; they were considered as curiosities and looked upon by scientists as such. In 1888, Mr. T. L. Willson began a series of experiments relating especially to the reduction of refractory metallic oxides by carbon, in an electrical furnace. By this method the reductions were to be accomplished by the heat effect of the current alone and not by electrolytic action.

The results of these experiments, which were numerous, and which extended over a period of years, developed some very interesting data as to the action of intense heat on refractory bodies generally, and especially as to the formation of carbides in large quantities. Mr. Willson found that lime, baryta, strontia, and even alumina, when subjected to the intense heat of his electric furnace, were liquefied and formed a molten mass, which could be brought to ebullition. An addition of carbon thereto caused a decomposition of the oxide, carbon monoxide being formed, while the fused metal united instantly with the excess of carbon, previously introduced, to form a carbide. Further experiments developed the fact that when a mixture of powdered lime and coke dust was introduced into the furnace, the mixture would melt down to a thick sirupy mass of practically pure carbide of calcium, and that this, when removed from the furnace and brought in contact with water, evolved acetylene gas in large quantities. The carbides of barium, strontium and aluminum also were prepared in the same manner, and the specimens now before you are the results of these earlier experiments.

We will now introduce a small quantity of each of these carbides into different vessels containing water at ordinary temperature. The carbides of barium, stontium and calcium decompose water readily, forming the respective hydrates of their metallic oxides and acetylene gas, which we now ignite as it is being evolved in each vessel; the resulting gas, as you observe, burns with a luminous sooty flame (see Fig. 1). As the carbide of aluminum does not react with water at ordinary temperatures, no gas is evolved from the fourth vessel.

This substantially completes the history of the alkali and alkaline earth metal carbides up to the date of Mr. Willson's discovery.

The physical and chemical properties of pure calcium carbide, as first prepared in the Willson furnace, and which we now hand you for inspection, is a dark brown, dense substance, having a crystalline metallic fracture of blue or brown appearance and a specific gravity of 2·262; it evolves a peculiar odor when exposed to the atmosphere, due to the action of atmospheric moisture. In a dry atmosphere it is odorless. When exposed to the air in lumps, it becomes coated with a layer of hydrate of lime, which, to a great extent, protects the rest of the substance from further deterioration by atmospheric moisture. It is not inflammable, and can be exposed to the temperature of the ordinary blast furnace without melting. When exposed to the flame of a Bunsen blast lamp it can be heated to a white heat, the exterior only being converted into lime. When brought into contact with water, or its vapor, at ordinary temperatures, it is rapidly decomposed, one pound generating, when pure, 5·892 cubic feet of acetylene gas at a temperature of 64° F. It also decomposes with snow at a temperature of —24° F. It is not acted upon by the vapor of water at high temperatures. It abstracts moisture readily from alcohol, also from liquefied ammonia gas, rendering the latter anhydrous. If small pieces are treated with common sulphuric acid, a violent reaction ensues. Acetylene is generated with considerable increase in temperature. If, however, large pieces are plunged into common sulphuric acid, the reaction is feeble.

An exhaustive series of experiments, made by Dr. H. Schweitzer, of New York, have shown that when treated at a red heat with dry muriatic acid gas, the carbide is decomposed with the formation of free carbon and small quantities of a yellow substance easily

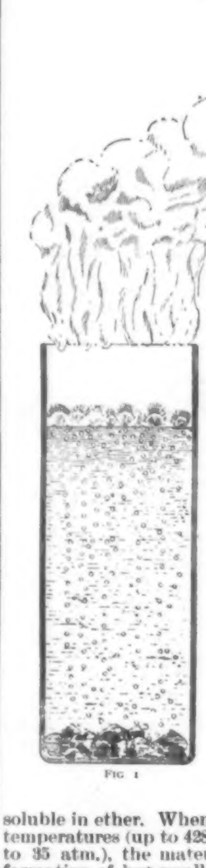


FIG 1


FIG 2


FIG 3

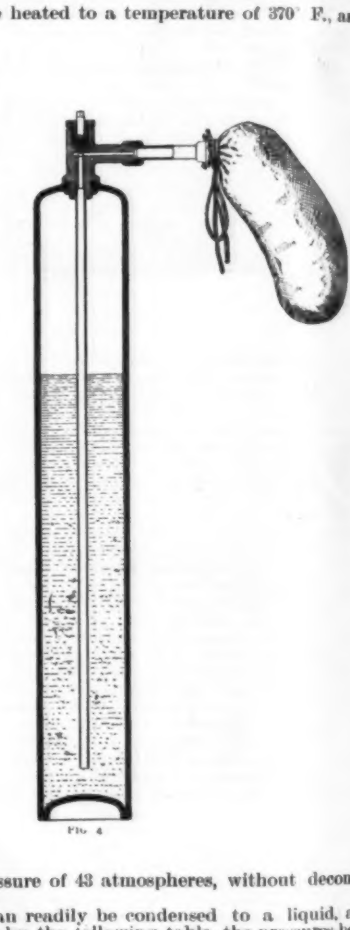


FIG 4

soluble in ether. When treated with steam at different temperatures (up to 428° F.), and different pressures (up to 35 atm.), the material was decomposed with the formation of but small quantities of the same yellow substance, and not in sufficient quantity for further examination.

Benzol, nitro-benzol, phenol, aniline, toluidine and other organic compounds, gave no reaction when treated with carbide of calcium alone, and in the presence of water, at varying pressures and temperatures. It would ap ear from the foregoing to be a very inert body in its action on other compounds, and in view of this fact, the ease with which it decomposes water at ordinary temperatures is remarkable.

When treated with water in a closed vessel properly cooled, acetylene gas continues to be evolved from the material at pressures exceeding 75 atm. Calcium carbide has the chemical formula CaC_2, and contains in 100 parts 62·5 parts of calcium and 37·5 parts of carbon.

The gaseous product of the decomposition of the alkali and alkaline earth metal carbides with water, namely, acetylene, is an unsaturated hydrocarbon of the series C_nH_{2n-2}, having the chemical formula C_2H_2, and containing, therefore, in 100 parts, 92·3 parts of carbon and 7·7 parts of hydrogen.

It was first recognized, and its chemical constitution determined, by Berthelot, in 1849. It has heretofore been formed in small quantities by passing ethylene, or the vapors of alcohol, wood alcohol, ether, and other organic compounds, through a red hot tube. It is present in coal gas to the extent of 0·06 per cent., and water gas contains almost 1·0 per cent. It has also been formed by passing hydrogen gas between carbon points brought to incandescence by the electric current, which is the first recorded synthesis of an organic compound directly from its elements. It can also be produced by the incomplete combustion of the vapors of ether, amylene, etc., or of illuminating gas, in the interior of a Bunsen burner; by passing the vapor of chloroform over red hot copper; or from chloroform and potassium amalgam; or from chloroform and sodium; or by the electrolysis of fumaric and malic acids; by passing the vapor of ethylene chloride over red hot soda lime; and finally, by allowing ethylene bromide to drop in a boiling concentrated solution of alcoholic potash, passing the impure acetylene into an ammoniacal cuprous chloride solution, washing the red precipitate with water, and, while still moist, boiling it with concentrated hydrochloric acid.

Acetylene is a colorless gas, having a penetrating pungent odor somewhat resembling garlic, which is of great importance in its application to household illumination, as it renders the slightest escape of gas in a room easily detectable. It has a specific gravity of 0·91 and burns with a luminous sooty flame. It is soluble in water in about the same proportions as carbon dioxide, that is, at 64° F. water will absorb its own volume of the gas. Absolute alcohol and glacial acetic acid dissolve about six times their volume. It is practically insoluble in saturated brine, 100 volumes absorbing but five volumes of the gas, whereas paraffine will absorb two and one-half times its volume. By heating acetylene to the softening point of glass, benzol (C_6H_6), styrolene (C_8H_8), naphthalene ($C_{10}H_8$), anthracene ($C_{14}H_{10}$) and reten ($C_{18}H_{18}$) are formed.

With an alkaline solution of permanganate of potash, acetylene is oxidized to oxalic acid, and with a dilute solution of chromic acid to acetic acid. By treating acetylene copper with zinc and ammonia, ethylene is formed, and a mixture of acetylene and hydrogen, brought in contact with platinum black, forms ethane. By the electric spark, acetylene is resolved into carbon and hydrogen, at the same time a fluid and a solid poly-acetylene are formed; the latter resembles horn and is insoluble in the ordinary solvents. A mixture of nitrogen and acetylene is converted by the induction spark into hydrocyanic acid.

It may be heated to a temperature of 370° F., and under a pressure of 43 atmospheres, without decomposition.

The gas can readily be condensed to a liquid, as is evidenced by the following table, the pressures being considerably less than those required for carbon dioxide.

Acetylene.		Carbon Dioxide.	
Fah.	Atmospheres.	Fah.	Atmospheres.
—116°	1	—112°	1
— 28·6°	9	— 29 2°	12·7
— 9·4°	11·01	— 4°	19·93
+ 14°	17·06	+ 14°	26·76
32°	21·53	32°	35·40
41·45°	25·48	41°	40·47
56·3°	32·77	59°	52·17
67·27°	39·76	68°	58·84

The critical point of the gas has been placed by Ansdell at 98·69° F. He also determined the specific gravity of the liquefied gas at various temperatures, placing the density at about one-half that of carbon dioxide; but his results do not agree with those obtained by us in the production and storage of large quantities of the liquefied gas. For instance, the small tank to which this connecting pipe and burner are attached (Fig. 2) should contain, according to Ansdell, when filled at 69·08° F., about 2·15 pounds of liquefied acetylene; as a matter of fact, however, we can fill into this tank somewhat more than two and three-quarter pounds of the liquefied gas. We are now engaged in preparing a new table of pressures and specific gravities of the liquefied gas, and will be pleased to communicate the results to you at a later date. One pound of the liquid, when evaporated at 64° F., will produce fourteen and one-half cubic feet of gas at atmospheric pressure; or a volume 400 times larger than that of the liquid.

The odor of the gas has already been made apparent to you while the experiment showing the decomposition of the various carbides with water was being carried on. We will now show you the liquefied gas contained in this glass tube surrounded by a metal

* A paper read at a meeting of the Franklin Institute, Philadelphia, March 20, 1895.—From the Journal of the Institute.

casing (Fig. 3). As you will observe, the liquefied gas forms a colorless, mobile, highly refractive liquid, which, when the pressure is slightly relieved, commences to boil and evolves a gas which, ignited as it issues from this gas tip, burns with an intensely white flame. If the liquefied gas be suddenly relieved of its pressure, or allowed to escape in its liquefied state to the atmosphere, a portion evaporates rapidly, thereby abstracting from the remaining portion sufficient heat to solidify it. This tank, which is now shown you (Fig. 4), contains liquefied acetylene, which has been cooled to a temperature of —28° F., in order to prevent the escape of too large a volume of gas during the process of its solidification. Attached to this valve, inside of the tank, is a tube which reaches within half an inch of the tank bottom, and is open at its lower end. We now attach to the valve a flannel bag to receive the solidified gas. Upon opening a valve the liquefied gas escapes, the solidified portion remaining in the bag, while the gas formed escapes through the pores of the bag. This bag will hold about three-quarters of a pound of the solidified gas, and this is about the quantity which is now being emptied on the plate. A portion of this solidified gas will now be passed to you for inspection; another portion is packed into this wooden tube, a thermometer is inserted (Fig. 5), and, as you will observe, the temperature falls to —118° F. Another portion is placed on one pound of mercury contained in this saucer (Fig. 6); the intense cold of the solidified gas almost immediately solidifies the liquid metal. A portion of the solidified gas or "acetylene snow" is now dropped into this vessel (Fig. 7), containing water. Being lighter than water, it floats upon its surface, and when touched with a light the gas surrounding each particle of the solidified gas burns with a sooty flame, and continues to burn until all the solidified gas has disappeared. I will now ignite the gas evolving from the acetylene snow contained in this dish, and you have the interesting exhibit of a solidified gas at —118° F. giving off gas which can be

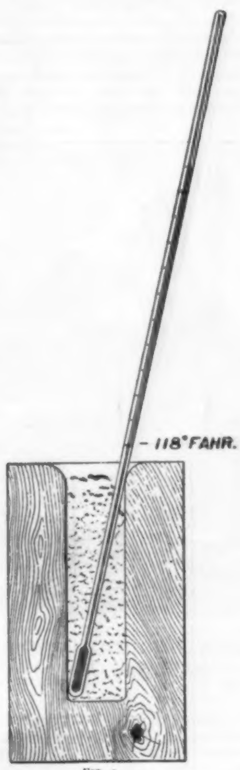


FIG. 5

ignited, and which, although evolved at this low temperature, possesses the same illuminating power as at higher temperatures.

You have now seen acetylene in its three physical conditions, namely, as a gas, a liquid and a solid; and the mere fact that it readily assumes the gaseous and liquid condition is of vital importance to its commercial application.

(To be continued.)

THE MANUFACTURE OF CASTOR OIL.

THE system hitherto in use at the centers of this industry involves, first of all, the separation of the husks from the kernels, which are then heated and moulded into cakes and placed in horsehair bags or cloths and submitted to pressure, which is almost invariably obtained by manual power in India. In Marseilles and other centers of Europe where castor oil is manufactured, hydraulic pressure is usually applied. In the case of East Indian oil, the total oil taken from the seed is usually extracted at one operation; but where hydraulic pressure is employed it is found more economical to press twice, and by this means extract a larger percentage of oil from the seed. The Calcutta marc from castor crushing contains about 20 per cent. of oil, whereas by the other systems it is considerably less than half that amount. This mode of manufacture has many objectionable features, being complicated and unnecessarily expensive and most injurious as regards the quality of both the oil and the cake so produced.

The system adopted by the British Castor Company, Limited, at their works, which are situated on Shenton Street, London, S. E., has been introduced by their consulting engineer, who has invented and patented most of the apparatus employed. Guzzerat seed is exclusively employed for the preparation, both of the medicinal and the lubricating oils, so as to insure a uniform product, as it is the only variety which can readily be obtained free from admixture.

The first floor of the building is used as a granary, and here the seed is carefully sifted, so as to get rid of any extraneous matter. It is then shot into a movable hopper, which is drawn along the top of the large horizontal hydraulic press situated on the ground floor. When the press boxes are open the seed is discharged through the aperture at the bottom of the hopper, and fills the boxes. A pressure of 480 tons is then applied, and the oil is expressed, falling upon a movable plate and into drains provided for its reception along each side of the press. From these sources it flows into a linen strainer, which separates the crushed seeds which have escaped from the press, and then into an adjacent tank. Here, when it reaches a certain level, the stopcock of a vacuum pipe in connection is opened, and the oil is immediately drawn through a system of pipes into a cylinder on the first floor in another part of the building, whence it passes down into the first filter, which takes out all mechanical impurities. Thence it is drawn into another cylinder adjacent to the first, one being empty while the other is full, and vice versa. At this stage it may be noticed that the oil is perfectly clear and bright. However, in order to get rid of microscopical impurities it passes from the second cylinder into a second filter, whence it is drawn into the bottling machine, where, as a final precaution, it is again filtered before being run into the bottle. This apparatus, which has been patented by Mr. Mitchell, is admirably adapted for the purpose, and, as a vacuum is formed in the bottle when the outlet taps are opened, cracked bottles are at once detected. The temperature both of the filling and bottling rooms is kept uniform day and night.

It may here be remarked that the system of filtration is throughout entirely mechanical, no chemicals being employed in any part of the process. In the case of the medicinal oil, four separate cloths of a special kind of twill are arranged in each filter. The plant has been erected about four months only, and medicinal oil is expressed during the first half of the week, the press being afterward used for the extraction of lubricating oil from the residue; but from the press forward the two varieties of oil pass through distinct and separate systems of pipes and refining plant, so as to avoid any possible contact between them. Shortly, however, the two varieties of oil will be made continuously, a separate press being used for each. It may here be noted that the oil expressed by this process is absolutely "cold drawn," the temperature of the press room averaging 47° Fah.

This is of interest, in view of the fact that very little, if any, of the so-called "cold drawn" castor oil at present in the market is properly so termed. The oil, in all its stages of manufacture, has a simple, bland taste, resembling olive or almond oil, in marked contrast to the nauseous taste usually associated with it. The press takes a charge of 2 cwt. of seed at each operation, the time occupied in expressing the medicinal oil being about seventeen minutes. An important fea-

FIG 6.

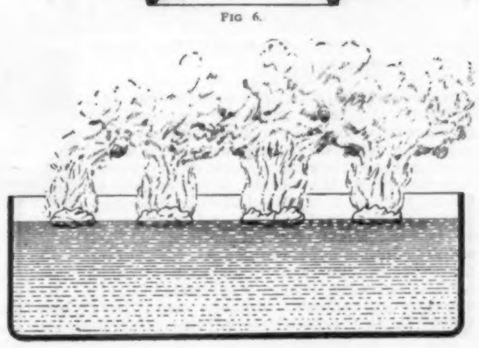


FIG. 7.

ture of this system of vacuum filtration is that from the time the oil leaves the collecting tank until bottled it is never exposed to the air, and the natural moisture of the oil is dissipated mechanically.

After the seed has undergone the first pressure, whereby half of the available 44 per cent. of oil has been collected for medicinal purposes, the residual cake is again submitted to the same treatment. This takes out an additional 16 per cent. of oil, finally leaving about 6 per cent. in the marc. The second product goes through a similar process to the first, except that it is only filtered once, and that three instead of four cloths are employed for the purpose. The finished product, which is sold exclusively for lubricating purposes, as a matter of fact closely resembles the medicinal oil, but has a slightly nauseous taste. The marc left after the second extraction is at present entirely used for horticultural purposes under the name of "Foodite." Analysis shows it to contain 7·28 per cent. of nitrogen, equivalent to 8·84 per cent. of ammonia.

Mr. Mitchell was engaged in the manufacture of castor oil in India for some twelve years, and the process now employed by him embodies all the best points of his experience in the different oil-producing centers. In Calcutta alone there are more than 300 mills engaged in crushing castor oil seed, but the system there employed, as already explained, involves the husking of the seed prior to submitting it to pressure. However, a mill is being erected there in which Mitchell's process has been adopted. The advantages claimed for crushing the whole seed are that the process is much more expeditious, less costly, and that there is no danger of internal pressure, such as is liable to occur when the kernels only are submitted to pressure.

Obviously this system of extraction is applicable to many other seeds besides castor. In fact, it has been tried with extremely satisfactory results with linseed. In this instance, after about 27 per cent. of oil had been extracted by cold pressure, the seed was but little altered in appearance, and would doubtless be very useful in that state for cattle food, the expense of making it into cake being unnecessary. Besides this, several purposes for which it could with advantage be used pharmaceutically suggest themselves. The most important economic use of the seed, however, is as a source of oil.

CONVERSAZIONE OF THE ROYAL SOCIETY.

AT the recent conversazione of the Royal Society under the presidency of Lord Kelvin, Lord Armstrong exhibited some lantern slide projections of the results of recent experiments on the electric discharge in air, showing various phases, hitherto unobserved, of the brush discharge accompanying the electric spark, and the effect of induction on the results. The figures were striking in appearance and of considerable symmetry. The luminous effects were delineated by instantaneous photography, and the mechanical effects by the electric action on dust plates. The spark itself had to be taken in a dark box on a shunt line, as its strong light and violent action would otherwise be incompatible with the photographic and mechanical methods used in the experiments; but nearly the same tensions were obtained outside the box as within.

Professor Ewing exhibited a magnetic tester for measuring hysteresis in iron, and a representation of the instrument is given in Fig. 1. It consists of a mag-

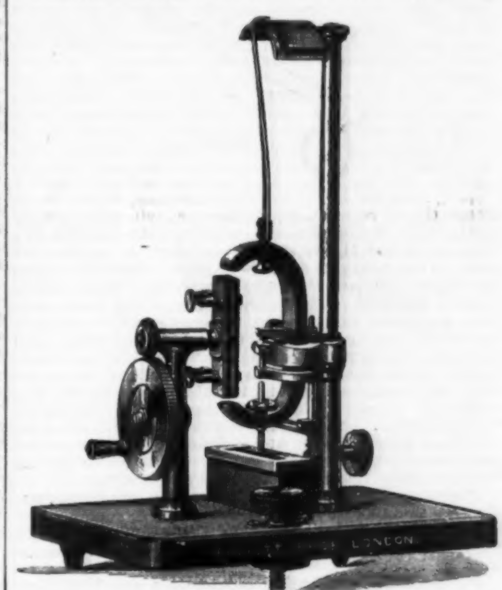


FIG. 1.

MAGNETIC TESTER FOR HYSTERESIS IN IRON.

net suspended on a knife edge, and the magnet is deflected in consequence of the work expended in overcoming the magnetic hysteresis of the pieces of iron to be tested, which in lengths of 3 in. are clamped in a carrier, and caused to revolve before the poles of the magnet. The amount of deflection is observed by means of a pointer, shown in the cut, and moving over a divided scale; this serves as a measure of the hysteresis. The apparatus is so designed as to make the induction nearly the same in all specimens, notwithstanding differences of permeability. Two standard samples, with Professor Ewing's certificate, are provided with the instrument, having stated amounts of hysteresis, and the test of any other specimen is made simply by comparing the deflection produced by it with the deflections produced by the standard samples. The hysteresis of each of the standard samples is stated for B = 4,000 in ergs per cubic centimeter for each double reversal of magnetism, and also in the number of watts per lb., which would be expended if double reversals of magnetism took place with a frequency of 100 per second. This value of B (4,000) is taken as a convenient standard of reference, but if it is desired to find the hysteresis for any other induction, the following table of factors can be used:

Induction B.	Relative amounts of hysteresis.
2,000	0·33
2,500	0·47
3,000	0·63
4,000	1·00
5,000	1·41
6,000	1·89
7,000	2·41
8,000	3·00

Mr. L. Pyke exhibited what he called "the hydrogen wall," made as an attempt to obtain greater efficiency in the reduction of electro-positive metals from aqueous solutions, and forming an amalgam with mercury as a cathode. He had a glass cell, with a central cylindrical porous pot, nearly filled with mercury; the outer vessel was filled with solution of caustic potash and contained also a cathode of thin sheet lead. The current was taken from the street mains, and potassium from the potash solution was thrown down with fair rapidity as an amalgam with the mercury. For other metals other aqueous solutions replace that of potash. Mr. Pyke says that by the usual method local action soon sets in, and hydrogen is liberated freely. This is chiefly due to the ease with which large quantities of the circulating liquid obtain access to the amalgam surface, and is further facilitated by the fact that the mercury cathode being placed at the bottom of the depositing vessel, such amalgam as is initially formed tends to float upon it, and thus exists in the form richest in the positive metal immediately at the point of contact with the liquid. It therefore being advisable to obtain the amalgam in its most concentrated form as far as possible from the point of liquid contact, and to prevent by some means the evolution of hydrogen, it is deemed expedient to place the mer-

cury cathode in a porous vessel, for the purpose. The effect of this is to produce the desired result. It was seen that the amalgam is in its richest condition at the top of the porous vessel, which is the point farthest removed from the liquid—where it is not subject to any appreciable extent to the corroding effect of the liquid electrolyte—from which it may be skimmed. The precise action of the device in the prevention of the liberation of hydrogen at the electrolytic contact surface may be open to debate, but the fact certainly exists that the hydrogen is not liberated to anything like the extent to which it would be were the amalgam exposed.

Major Holden, R.A., exhibited some transparent electric meters, in which the indicating needle moved between two plates of glass, or rather in a box with glass ends, so that the arrangement could be placed in front of the condensers of an optical lantern, and the indicating needle represented on the screen in magnified form, by means of a projection lens. This plan also gives the advantages of small working parts in the instruments themselves, such as dead beat action and small consumption of energy in working.

Mr. Wimshurst exhibited a gradient indicator, designed to meet the needs of naval architects and civil engineers, for measuring frequently varying angles of inclination. Fig. 2 may help to give an idea of the instrument.

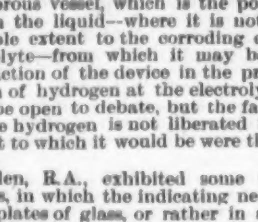


FIG. 2

A tube, A, about three-quarters of an inch in diameter, contains mercury, and is placed vertically; its ends, K and H, are thin tubes which turn over so as to lie horizontally, and are so placed that the dotted line shows the center of the oscillations which they have to indicate. The thinner parts of the tube contain a lighter liquid than mercury—say water and ink—and the smallness of these parts of the tube magnifies the motions of the mercury. In the horizontal tubes pieces of iron with beads at the ends show the maximum extent to which the liquid has oscillated in any given time, as in the registering thermometer. The motion may be adjusted so as to be either quick or slow, and is dead beat. It may be used, as an example, to show the maximum extent to which a vessel has rolled during a given watch.

Professor Ramsay, by means of a spectroscope, showed the spectrum of argon, also the spectrum of mixed argon and helion, and that the D line of helion is not identical with either of the D lines of sodium.

Professor J. A. Fleming exhibited a synchronizing alternating current motor and contact maker, for the delineation of the form of alternating current and electromotive force curves, and a form of resistance of small inductance for use with the apparatus. A large collection of curves was shown, taken at the Bankside Station of the City of London Electric Lighting Company; they are analogous to indicator diagrams in the case of a steam engine. A form of resistance of small self-induction and very large radiative power is exhibited. Such a resistance is required to divide the potential in delineating the curves of high pressure alternators. This resistance consists of very fine platinoid wire wound longitudinally over porcelain insulators, which are kept pressed apart by a spiral spring. The wire is thus kept tight even when expanded by rise of temperature. Each of these resistance cages is constructed to dissipate 100 watts, and twenty cages are placed in series when working on a 2,000 volt circuit.

Messrs. Johnson, Matthey & Company exhibited valuable specimens of metals of the platinum group, as shown also at the Royal Institution; and, if we remember rightly, they were the same as placed on view at the recent exhibition at Antwerp. The chief specimen was a palladium ingot weighing 1,000 oz., and extracted from £2,250,000 worth of gold.

Professor W. M. Hicks exhibited an instrument for analyzing primary and secondary volts and amperes simultaneously. Mr. Sidney Waters exhibited astronomical charts and Mr. Norman Lockyer a photographic spectrum of α Orionis. Mr. R. E. Crompton a potentiometer and platinum thermometers for use therewith, Sir B. W. Richardson an electrical cabinet for use in hospital wards, Mr. Hermann Kuhne exhibited Junker's patent calorimeter, and Dr. John Shields a mechanical device for performing temperature corrections in barometers.

Mr. T. Clarkson exhibited an instrument—shown open in Fig. 3—called the "circlograph," for drawing

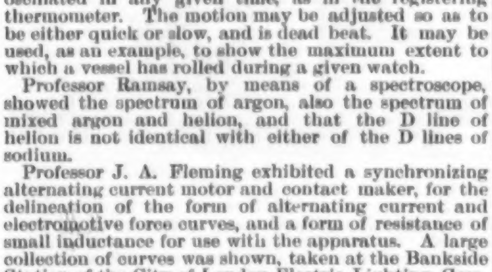


FIG 3

and measuring circular curves of any large radius without requiring the center. The construction of these instruments is based upon a recent discovery that it is possible to cut a flat piece of steel—of uniform thickness and temper—into a certain form, which imparts to it the property of always bending into circular curves. If the plate is required to bend into curves of comparatively short radius—say 12 in.—it is made straight upon one of the long edges, the ends are squared, and the other edge is cut into the approximate form of a rectangular hyperbola, of which the long straight edge is a symmetrical chord. Such a plate, when bent by end compression, gives circular curves. For curves of very large radii, another plan is adopted.

Mr. W. N. Shaw exhibited four globes, illustrating phenomena connected with the formation of cloud under the influence of convection currents; sometimes the mists had a cyclonic motion; he also showed the formation of a cloud by the dynamical cooling of the air, equivalent to an elevation of 10,000 ft. He likewise demonstrated that cloud formation introduces modifications into the dynamical cooling of air.

Dr. Hopkinson exhibited some effects of currents in iron on its magnetization, by means of two comparatively small coils buried in the substance of a large electro-magnet. Professor Roberts-Austen exhibited the electrical furnace he used in his recent lecture at the Royal Institution, and melted some refractory metals therewith. Professor Ayrton exhibited students' simple electrical apparatus for determining with rapidity the mechanical equivalent of heat, with an accuracy within 1 per cent. The Cambridge Scientific Instrument Company an improved rocking microtome, spectrometer, and Donkin's harmonograph. Professor George Forbes his torsion model imitation of a submarine cable, recently described in these pages. Professor Vivian B. Lewes the preparation of acetylene from calcic carbide. Mr. R. Inwards exhibited specimens of curious joints in carpentry, consisting of remarkable mortises, all made without compression or veneering, serving as exercises for ingenuity, and showing how apparently impossible castings can be drawn from moulds of complicated form. Mr. F. W. Lanchester exhibited a new addition to the slide rule, making it applicable at once to the calculation of whole or fractional powers, and rendering it specially useful for the solution of problems in thermodynamics. Professor A. Liversedge exhibited sections of gold nuggets etched to show crystalline structure; and Professor Gotch, with Dr. H. O. Forbes, by permission of the Corporation of Liverpool, a living specimen of the Malapterurus electricus from the river Senegal. The specimen was but about 6 in. long, but gave unpleasantly powerful shocks. It is a fish which is found also in the Nile. Mr. Francis Galton exhibited enlarged photographs of finger prints, with descriptive notation, illustrating methods recently adopted in the police departments.

Major Cardew exhibited specimens of the deposit or incrustation on the insulators of the electric light mains at St. Pancras, in which metallic sodium and potassium have been found, and of the insulators and wood bearers which were in use on these mains. The deposit was found to have been caused by the passage of alkaline salts in solution to the negative main, the salts being chiefly derived from the neighboring soil, with which the end fibers of the wood bearers were in contact. Electrolysis of these salts took place with liberation of the metals at the negative main, the metals being oxidized and slowly carbonated in air. During this process nodules of the metal seem to have become embedded in the oxides and preserved from oxidation.

APPARATUS FOR THE DEMONSTRATION OF RESONANCE.

THE more we study what is taking place around us, the more we become impressed with the importance of the transmission of energy by elastic intermedia. In examining the matter more closely, we see that in all periodical phenomena there is a sort of synchronization, as was shown by Mr. Cornu in a magistral manner some time ago, at a meeting of the International Society of Electricians.

If we approach the problem by calculation, we see that when a periodical movement is transmitted through the intermedium of an elastic member to a system capable of oscillating with a proper period, the receiver will borrow very different motions from the exciter, according to the conditions of the proper oscillations of the two movables and the qualities of the transmitting member. Three factors especially play a part in the phenomenon. These are the durations of the oscillations of the exciter and receiver, and the deadening of the system. Such deadening, which is due to a dissipation of energy through friction or any other cause, may have its seat in any part whatever of the whole. The result will be essentially different according to its value and the place where it is greater.

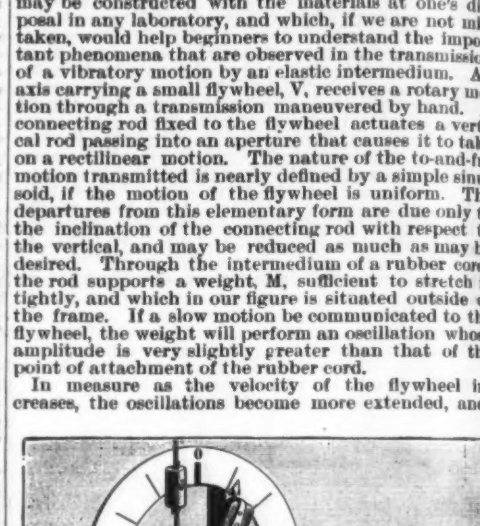
In the absence of any deadening, the receiving member takes on a motion that is a complicated combination of the oscillations of the two parts of the system. The oscillations are now rapid and of great amplitude and now slower (at least in appearance), and so slightly pronounced that the body seems for an instant to come to rest; but it is only to immediately resume its oscillatory motion. These periods bordering on rest are so much the more approximate in proportion as the two systems are more discordant. When a concordance of the periods is approached, the motions of feeble amplitude are spaced further and further apart, while the greater elongation of the motion much increases. In acoustics, this phenomenon corresponds to a sound interrupted by beats. Finally, when we reach unison, the energy of the source passes entirely to the receiver, and if it is kept up in a continuous manner, the motion of the latter will increase beyond all limits.

When a deadening exists, things take place a little differently. If it is in the exciter, its motion will cease at the end of an instant and the receiver will continue to vibrate with its proper period. This is the case studied by Messrs. Sarasin and De la Rive for electric vibrations. The true reason for the phenomenon has been given by Mr. Poincare.

When, on the contrary, the receiver contains a cause of dissipation of energy, it takes fatally the impress of the exciting motion, and its proper period disappears entirely at the end of a varying length of time. The amplitude of the motion then depends upon the difference of the periods and on the deadening of the receiver. The importance of this particular case has been demonstrated by Helmholtz, apropos of the organ which vibrates in our ear in unison with the motions that reach it, and transmits its excitation to the nervous extremities that end in the microscopic lamellæ discovered by Corti.

If we pass to more familiar, if not more frequent, examples, we find applications of resonance at every instant. In the transmission of the energy of a gas or steam motor through the Raffard elastic system, experience shows that the variations of speed of the receiving machine, dynamo or machine tool are attenuated or re-enforced by the coupling, according to the ratio of the proper periods of the motor and of the receiver coupled upon the transmission. It is even more important than might be supposed, a priori, to avoid in certain cases the oscillations communicated to the frame of a motor in consequence of a want of equilibrium of the flywheel. Recently, in a large Parisian establishment, a gas motor, whose flywheel was thrown out of balance by a few pounds only, had to be regulated anew, because, by reason of the concordance of its period with that of the proper oscillations of the building, the latter took on a motion of great amplitude that even endangered its safety. All such consequences of an absolute theory may be brought clearly to light by means of a very simple apparatus that may be constructed with the materials at one's disposal in any laboratory, and which, if we are not mistaken, would help beginners to understand the important phenomena that are observed in the transmission of a vibratory motion by an elastic intermedium. An axis carrying a small flywheel, V, receives a rotary motion through a transmission maneuvered by hand. A connecting rod fixed to the flywheel actuates a vertical rod passing into an aperture that causes it to take on a rectilinear motion. The nature of the to-and-fro motion transmitted is nearly defined by a simple sinusoid, if the motion of the flywheel is uniform. The departures from this elementary form are due only to the inclination of the connecting rod with respect to the vertical, and may be reduced as much as may be desired. Through the intermedium of a rubber cord, the rod supports a weight, M, sufficient to stretch it tightly, and which in our figure is situated outside of the frame. If a slow motion be communicated to the flywheel, the weight will perform an oscillation whose amplitude is very slightly greater than that of the point of attachment of the rubber cord.

In measure as the velocity of the flywheel increases, the oscillations become more extended, and,



APPARATUS FOR THE STUDY OF RESONANCE.

when there is a concordance between the primitive motion and the duration of the proper oscillation of the weight, the latter executes motions that are entirely disordinate. The velocity still increasing, the oscillations gradually decrease until they become scarcely perceptible, when the extremity of the cord moves with very great speed. All the energy then remains stored up in the transmission in a potential state. When, on the contrary, there is a resonance, it passes to the kinetic state, and, in all other cases, the system is the seat of a continual transformation of one form to the other. The last case, in which the energy remains entirely in the transmission, is very important in one particular domain, that of transportation. The springs of carriages, and the rubber tires of bicycles, in fact, experience on the part of the wheel a series of distortions that produce variations in their tension that are too rapid to be transmitted.

The phenomena are rendered more striking by the arrangement seen at the left of the figure. The axis, B, may be connected with the flywheel, V, by a rod that communicates an oscillatory motion to it. Its crank, in fact, is longer than that of the driving gear. A piece, P, loose upon the axis, represents the receiving system. A spiral spring connects the piece, P, with the axis.

We shall see, also, according to the velocity of the flywheel, the piece, P, so oscillate as to make an entire revolution or even more, or else fix itself so well that we shall no longer observe anything except a slight trembling of the needle that it carries.

The necessity of the concordance of motions for the production of oscillations of great amplitude will become evident if we prolong the transmission by a cord and an elastic coupling terminating in a weight, N, suspended by a rubber cord. If care be taken to regulate the proper oscillations of the piece, P, and the weight so that their period shall be slightly different, we shall observe that the amplitudes are very different for the same velocity of the exciting motion. The same demonstration may be made by placing upon the axis, B, two pieces having different oscillations, either by reason of their moment of inertia or on account of the connection.

There are no greater difficulties in the introduction of a certain deadening into the receiving system. It

suffices, for example, to mount upon the piece, P, a strip of wood whose plane passes through the axis of rotation. We shall thus verify the consequences relative to the synchronization of deadened motions.—C. E. Guillaume, in La Nature.

(1) "ON THE ELECTRIFICATION OF AIR."*

§ 1. CONTINUOUS observation of natural atmospheric electricity has given ample proof that cloudless air at moderate heights above the earth's surface, in all weathers, is electrified with very far from homogeneous distribution of electric density. Observing, at many times from May till September, 1859, with my portable electrometer on a flat open sea beach of Brodick Bay, in the Island of Arran, in ordinary fair weather at all hours of the day, I found the difference of potentials, between the earth and an insulated burning match at a height of 9 ft. above it (2 ft. from the uninsulated metal case of the instrument, held over the head of the observer) to vary from 200 to 400 Daniell's elements, or as we may now say volts, and often during light breezes from the east and northeast it went up to 3,000 or 4,000 volts. In that place, in fair weather, I never found the potential other than positive (never negative, never even down to zero), if for brevity we call the earth's potential at the place zero. In perfectly clear weather under a sky sometimes cloudless, more generally somewhat clouded, I often observed the potential at the 9 ft. height to vary about 300 volts gradually to three or four times that amount, and gradually back again to nearly the same lower value in the course of about two minutes.† I inferred that these gradual variations must have been produced by electrified masses of air moving past the place of observation. I did not remark then, but I now see, that the electricity in these moving masses of air must, in all probability, have been chiefly positive to cause the variations which I observed, as I shall explain to you a little later.

§ 2. Soon after that time a recording atmospheric electrometer‡ which I devised, to show by a photographic curve the continuous variation of electric potential at a fixed point, was established at the Kew Meteorological Observatory, and has been kept in regular action from the commencement of the year 1861 till the present time. It showed incessant variations quite of the same character, though not often as large as those which I had observed on the sea beach of Arran.

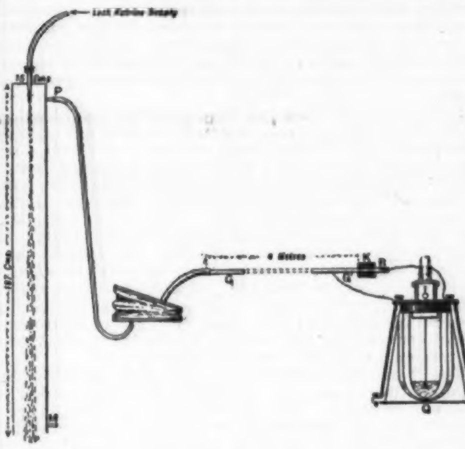
Through the kindness of the Astronomer Royal, I am able to place before you this evening the photographic curves for the year 1893, produced by a similar recording electrometer which has been in action for many years at the Royal Observatory, Greenwich. They show, as you see, not infrequently, during several hours of the day or night, negative potential and rapid transitions from large positive to large negative. Those were certainly times of broken weather, with at least showers of rain or snow or hail. But throughout a very large proportion of the whole time the curve quite answers to the description of what I observed on the Arran sea beach thirty-six years ago, except that the variations which it shows are not often of so large amount in proportion to the mean or to the minimums.

§ 3. Thinking over the subject now, we see that the gradual variations, minute after minute through so wide a range as the 3 or 4 to 1 which I frequently observed, and not infrequently rising to twenty times the ordinary minimum, must have been due to positively electrified masses of air, within a few hundred feet of the place of observation, wafted along with the gentle winds of 5 or 10 or 15 feet per second which were blowing at the time. If any comparably large quantities of negatively electrified air had been similarly carried past, it is quite certain that the minimum observed potential, instead of being in every case positive, would have been frequently large negative.

§ 4. Two fundamental questions in respect to the atmospheric electricity of fair weather force themselves on our attention: (1) What is the cause of the prevalent positive potential in the air near the earth, the earth's potential being called zero? (2) How comes the lower air to be electrified to different electric densities whether positive or negative in different parts? Observations and laboratory experiments made within the last six or eight years, and particularly two remarkable discoveries made by Lenard, which I am going to describe to you, have contributed largely to answering the second of these questions.

§ 5. In an article "On the Electrification of Air by a Water Jet," by Magnus Maclean and Makita Goto,§ experiments were described showing air to be negatively electrified by a jet of water shot vertically down through it from a fine nozzle into a basin of water about 60 centimeters below it. It seemed natural to suppose that the observed electrification was produced by the rush of the fine drops through the air; but Lenard conclusively proved, by elaborate and searching experiments, that it was in reality due chiefly, if not wholly, to the violent commotions of the drops impinging on the water surface of the receiving basin, and he found that the negative electrification of the air was greater when they were allowed to fall on a hard slab of any material thoroughly wetted by water than when they fell on a yielding surface of water several centimeters deep. He had been engaged in studying the great negative potential which had been found in air in the neighborhood of waterfalls, and which had generally been attributed to the inductive action of the ordinary fine weather electric force, giving negative electricity to each drop of water spray before it breaks away from conducting communication with the earth. Before he knew Maclean and Goto's paper, he had found strong reason for believing that that theory was not correct, and that the true explanation of the electrification of the air must be found in some physical action not hitherto discovered. A less thorough inquirer might have been satisfied with the simple explanation of the electricity of waterfalls naturally suggested by Maclean and Goto's result, and might have rested in the belief that it was due to an electrifying effect produced by the rush of the broken water through the air; but Lenard made an independent experimental investigation in the physical laboratories of Heidelberg and Bonn, by which he learned that the seat of the negative electrification of the air electrified is the lacerated water at the foot of the fall, or at any rocks against which the water impinges, and not the multitudinous interfaces between air and water falling freely in drops through it.

§ 6. It still seems worthy of searching inquiry to find electrification of air by water falling in drops through it, even though we now know that, if there is any such electrification, it is not the main cause of the great negative electrification of air which has been found in the neighborhood of waterfalls. For this purpose an experiment has been very recently made by Mr. Maclean, Mr. Galt, and myself, in the course of an investigation regarding electrification and diselectrification of air with which we have been occupied for more than a year. The apparatus which we used is before you. It consists of a quadrant electrometer connected with an insulated electric filter* applied to test the electrification of air drawn from different parts of a tinned iron funnel, 187 centimeters long and 15 centimeters diameter, fixed in a vertical position with its lower end open and its upper end closed, except a glass nozzle, of 1·6 mm. aperture, admitting a jet of Glasgow supply water (from Loch Katrine) shot vertically down along its axis. The electric filter (R in the drawing), a simplified and improved form of that described



in the Proceedings of the Royal Society for March 21, consists of twelve circles of fine wire gauze rammed as close as possible together in the middle of a piece of block tin pipe of 1 cm. bore and 2 cm. length. One end of it is stuck into one end of a perforation through a block of paraffin, K, which supports it. The other end (G′) of this perforation is connected by block tin pipe (which in the apparatus actually employed was 4 meters long, but might have been shorter) and India rubber tubing through bellows to one or other of two short outlet pipes (M and P) projecting from the large funnel.

§ 7. We first applied the India rubber pipe to draw air from the funnel at the upper outlet, P, and made many experiments to test the electricity given by it to the receiving filter, R, under various conditions as to the water jet; the bellows being worked as uniformly as the operator could. When the water fell fairly through the funnel with no drops striking it, and through 90 cm. of free air below its mouth, a small negative electrification of R was in every case observed (which we thought might possibly be attributable to electrification of the air where the water was caught in a basin about 90 cm. below the mouth of the funnel). But when the funnel was slanted so that the whole shower of drops from the jet, or even a small part of it, struck the inside of the funnel, the negative electrification of R was largely increased. So it was also when the shower, after falling freely down the middle of the funnel, impinged on a metal plate in metallic communication with the funnel, held close under its mouth, or 10 or 20 cm. below it. For example, in a series of experiments made last Monday (March 25), we found 0·28 of a volt in 15 minutes with no obstruction to the shower; and 4·18 volts in 5 minutes, with a metal plate held three or four centimeters below the mouth of the funnel; the air being drawn from the upper outlet (P). Immediately after, with P closed, and air drawn from the lower outlet (M), but all other circumstances the same, we found 0·20 of a volt in five minutes with no obstruction; and 6·78 volts in five minutes with the metal plate held below the mouth as before.

§ 8. These results, and others which we have found, with many variations of detail, confirm, by direct test of air drawn away from the neighborhood of the waterfall through a narrow pipe to a distant electrometer, Lenard's conclusion that a preponderatingly strong negative electrification is given to the air at every place of violent impact of a drop against a water surface, or against a wet solid. But they do not prove that there is no electrification of air by drops of water falling through it. We always found, in every trial, decisive proof of negative electrification; though of comparatively small amount when there was no obstruction to the shower between the mouth of the funnel and the catching basin 90 cm. below it. We intend to continue the investigation, with the shower falling freely far enough down from the mouth of the funnel to make quite sure that the air which we draw off from any part of the funnel is not sensibly affected by impact of the drops on anything below.

§ 9. The other discovery† of Lenard, of which I told you, is that the negative electrification of air, in his experiments with pure water, is diminished greatly by very small quantities of common salt dissolved in it, that it is brought to nothing by 0·011 per cent.; that positive electrification is produced in the air when there is more than 0·011 per cent. of salt in the water, reaching a maximum with about 5 per cent. of salt, when the positive electrical effect is about equal to the negative effect observed with pure water, and falling to 14 per cent. of this amount when there is 25 per cent. of salt in the solution. Hence sea water, containing as it does about 3 per cent. of common salt, may be expected to give almost as strong positive electrification to air as pure water would give of negative in similar circumstances as to commotion. Lenard infers that breaking waves of the sea must give positive electricity to the air over them; he finds, in fact, a recorded observation by Exner, on the coast of Ceylon, showing the normal positive electric potential of the air to be notably increased by a storm at sea. I believe Lenard's discovery fully explains also some very interesting observations of atmospheric electricity of my own, which I described in a letter to Dr. Joule, which he published in the Proceedings of the Literary and Philosophical Society of Manchester for October 18, 1859.* "The atmospheric effect ranged from 30° to about 420° [of a heterostatic torsion electrometer of 'the divided ring' species] during the four days which I had to test it; that is to say, the electrometric force per foot of air, measured horizontally from the side of the house, was from 9 to above 126 zinc-copper water cells. The weather was almost perfectly settled, either calm or with slight east wind, and in general an easterly haze in the air. The electrometer twice within half an hour went above 420°, there being at the time a fresh temporary breeze from the east. What I had previously observed regarding the effect of east wind was amply confirmed. Invariably the electrometer showed very high positive in fine weather, before and during east wind. It generally rose very much shortly before a slight puff of wind from that quarter, and continued high till the breeze would begin to abate. I never once observed the electrometer going up unusually high during fair weather without east wind following immediately. One evening in August I did not perceive the east wind at all, when warned by the electrometer to expect it; but I took the precaution of bringing my boat up to a safe part of the beach, and immediately found by waves coming in that the wind must be blowing a short distance out at sea, although it did not get so far as the shore. . . . On two different mornings the ratio of the house to a station about sixty yards distant on the road beside the sea was 0·97 and 0·96 respectively. On the afternoon of the 11th instant, during a fresh temporary breeze of east wind, blowing up a little spray as far as the road station, most of which would fall short of the house, the ratio was 1·08 in favor of the house electrometer—both standing at the time very high—the house about 350°. I have little doubt but that this was owing to the negative electricity carried by the spray from the sea, which would diminish relatively the indications of the road electrometer."

§ 10. The negative electricity spoken of in this last sentence, "as carried by the spray from the sea," was certainly due to the inductive effect of the ordinary electrostatic force in the air close above the water, by which every drop or splash breaking away from the surface must become negatively electrified; but this only partially explains the difference which I observed between the road station and the house station. We now know, by the second of Lenard's two discoveries, to which I have alluded, that every drop of the salt water spray, falling on the ground or rocks wetted by it, must have given positive electricity to the adjoining air. The air, thus positively electrified, was carried toward and over the house by the on-shore east wind which was blowing. Thus, while the road electrometer under the spray showed less electrostatic force than would have been found in the air over it and above the spray, the house electrometer showed greater electrostatic force because of the positively electrified air blown over the house from the wet ground struck by the spray.

§ 11. The strong positive electricity, which, as described in my letter to Joule, I always found in Arran with east wind, seemed at first to be an attribute of wind from that quarter. But I soon found that in other localities east wind did not give any very notable augmentation, nor perhaps any augmentation at all, of the ordinary fair weather positive electric force, and for a long time I have had the impression that what I observed in this respect, on the sea beach of Brodick Bay in Arran, was really due to the twelve nautical miles of sea between it and the Ayrshire coast east-northeast of it; and now it seems to me more probable than ever that this is the explanation when we know from Lenard that the countless breaking waves, such as even a gentle east wind produces over the sea between Ardrossan and Brodick, must every one of them give some positive electricity to the air wherever a spherule of spray falls upon unbroken water. It becomes now a more and more interesting subject for observation (which I hope may be taken up by naturalists having the opportunity) to find whether or not the ordinary fine weather positive electric force at the sea coast in various localities is increased by gentle or by strong winds from the sea, whether north, south, east or west of the land.

§ 12. From Lenard's investigation we now know that every drop of rain falling on the ground or on the sea,† and every drop of fresh water spray of a breaking wave, falling on a fresh water lake, sends negative electricity from the water surface to the air; and we know that every drop of salt water, falling on the sea from breaking waves, sends positive electricity into the air from the water surface. Lenard remarks that more than two-thirds of the earth's surface is sea, and suggests that breaking sea-waves may give contributions of positive electricity to the air which may possibly preponderate over the negative electricity given to it from other sources, and may thus be the determining cause of the normal fair weather positive of natural atmospheric electricity. It seems to me highly probable that this preponderance is real for atmospheric electricity at sea. In average weather, all the year round, sailors in very small vessels are more wet by

* Two communications to the Philosophical Society of Glasgow meeting, in the natural philosophy lecture room of the University of Glasgow, March 27, "On the Electrification of Air," "On the Thermal Conductivity of Rock at Different Temperatures."—From Nature.

† "Electrostatics and Magnetism" (Sir William Thomson), xvi, §§ 281, 282.

‡ "Electrostatics and Magnetism," xvi, §§ 271, 282.

§ Philosophical Magazine, 1890, second half year.

* Kelvin, Maclean, Galt, "On the Diselectrification of Air." Proc. Roy. Soc., March 14, 1895.

† "Ueber die Electricitat der Wasserfalle." Table xvii, p. 638. Annalen der Physik und Chemie, 1892, vol. xlvi.

* Republished in "Electrostatics and Magnetism." "Atmospheric Electricity," xvi, § 282.

† "Ueber die Electricitat der Wasserfalle." Annalen der Physik und Chemie, 1892, vol. xlvi, p. 631.

sea spray than by rain, and I think it is almost certain that more positive electricity is given to the air by breaking waves than negative electricity by rain. It seems also probable that the positive electricity from the waves is much more carried up by strong winds to considerable heights above the sea than the negative electricity given to the air by rain falling on the sea; the greater part of which may be quickly lost into the sea, and but a small part carried up to great heights. But it seems to me almost certain that the exceedingly rapid recovery of the normal fair weather positive, after the smaller positive or the negative atmospheric electricity of broken weather, which was first found by Beccaria in Italy 120 years ago, and which has been amply verified in Scotland and England,* could not be accounted for by positively electrified air coming from the sea. Even at Beccaria's observatory, at Garzegna di Mondovi, in Piedmont, or at Kew, or Greenwich, or Glasgow, we should often have to wait a very long time for reinstatement of the normal positive after broken weather, if it could only come in virtue of positively electrified air blowing over the place from the sea; and several days, at least, would have to pass before this result could possibly be obtained in the center of Europe.

§ 13. It has indeed always seemed to me probable that the rain itself is the real restorer of the normal fair weather positive. Rain or snow, condensing out of the air high up in the clouds, must itself, I believe, become negatively electrified as it grows, and must leave positive electricity in the air from which it falls. Thus rain falling from negatively electrified air would leave it less negatively electrified, or non-electrified or positively electrified; rain falling from non-electrified air would leave it positively electrified; and rain falling from positively electrified air would leave it with more of positive electricity than it had before it lost water from its composition. Several times within the last thirty years I have made imperfect and unsuccessful attempts to verify this hypothesis by laboratory experiments, and it still remains unproved. But I am much interested just now to find some degree of observational confirmation of it in Elster and Geitel's large and careful investigation of the electricity produced in an insulated basin by rain or snow falling into it, which they described in a communication published in the Sitzungsberichte of the Vienna Academy of Sciences of May, 1890. They find generally a large electrical effect, whether positive or negative, by rain or snow falling into the basin for even so short a time as a quarter of a minute, with, however, on the whole, a preponderance of negative electrification.

§ 14. But my subject this evening is not merely natural atmospheric electricity, although this is certainly by far the most interesting to mankind of all hitherto known effects of the electrification of air. I shall conclude by telling you very briefly, and without detail, something of new experimental results regarding electrification and diselectrification of air found within the last few months in our laboratory here by Mr. Maclean, Mr. Galt and myself. We hope before the end of the present session of the Royal Society to be able to communicate a sufficiently full account of our work.

§ 15. Air blown from an uninsulated tube, so as to rise in bubbles through pure water in an uninsulated vessel, and carried through an insulated pipe to the electric receiving filter, of which I have already told you, gives negative electricity to the filter. With a small quantity of salt dissolved in the water, or sea water substituted for fresh water, it gives positive electricity to the air. There can be no doubt but these results are due to the same physical cause as Lenard's negative and positive electrification of air by the impact of drops of fresh water or of salt water on a surface of water or wet solid.

§ 16. A small quantity of fresh water or salt water shaken up vehemently with air in a corked bottle electrifies the air, fresh water negatively, salt water positively. A "Winchester quart" bottle (of which the cubic contents is about two liters and a half), with one-fourth of a liter of fresh or salt water poured into it, and closed by an India rubber cork, serves very well for the experiment. After shaking it vehemently till the whole water is filled with fine bubbles of air, we leave it till all the bubbles have risen and the liquid is at rest, then take out the cork, put in a metal or India rubber pipe, and by double-acting bellows, draw off the air and send it through the electric filter. We find the electric effect negative or positive, according as the water is fresh or salt, shown very decidedly by the quadrant electrometer; and this, even if we have kept the bottle corked for two or three minutes after the liquid has come to rest before we take out the cork and draw off the air.

§ 17. An insulated spirit lamp or hydrogen lamp being connected with the positive or with the negative terminal of a little Voss electric machine, its fumes (products of combustion mixed with air) sent through a block tin pipe, 4 meters long and 1 centimeter bore, ending with a short insulating tunnel of paraffin and the electric filter, gives strong positive or strong negative electricity to the filter.

§ 18. Using the little biscuit canister and electrified needle as described in "our communication"† to the Royal Society "On the Diselectrification of Air," but altered to have two insulated needles with varied distances of from half a centimeter to two or three centimeters between them, we find that when the two needles are kept at equal differences of potential, positive and negative, from the inclosing metal canister, little or no electrification is shown by the electric filter; and when the differences of potential from the surrounding metal are unequal, electrification, of the same sign as that of the needle whose difference of potential is the greater, is found on the filter.

When a ball and needle point are used, the effect found depends chiefly on the difference of potentials between the needle point and the surrounding canister, and is comparatively little affected by opposite electrification of the ball. When two balls are used, and sparks in abundance pass between them, but little electricity is deposited by the sparks in the air, even when one of the balls is kept at the same potential as the surrounding metal. [The communication was illustrated by a repetition of some of the experiments shown on the occasion of a Friday evening lecture* on atmospheric electricity at the Royal Institution on May 18, 1860, in which one-half of the air of the lecture room was electrified positively and the other half negatively, by two insulated spirit lamps, mounted on the positive and negative conductors of an electric machine.]

* "Electrostatics and Magnetism," xvi, § 287.

† Proceedings of the Royal Society, March 14, 1895.

* "Electrostatics and Magnetism, xvi, §§ 285, 286.

(2) "ON THE THERMAL CONDUCTIVITY OF ROCK AT DIFFERENT TEMPERATURES."

Experiments by Lord Kelvin and Mr. Erskine Murray were described, and the apparatus used in them was shown, by which it was found that the thermal conductivity of specimens of slate, sandstone, and granite is less at higher temperatures than at lower for each of these rocks. The last tested was Aberdeen granite, for which experiments of fairly satisfactory accuracy showed the mean conductivity for the range from 146° C. to 215° C. to be 86 per cent. of the mean conductivity in the range from 81° C. to 146° C. They hope to send a communication to the Royal Society describing their work before the end of the present session. KELVIN.

PEROXIDE OF HYDROGEN AS A BLEACH.

PEROXIDE of hydrogen is a colorless, odorless liquid of nearly the same specific gravity as water, which, in appearance, it resembles very closely; it is, in fact, water slightly acidulated, which contains an extra amount of oxygen. Its bleaching qualities have been familiar to scientists for a long time, but its practical application has been greatly retarded by the inability to get it in such portable shape that it could be used when wanted and as wanted, and to produce it cheaply enough to be available for all classes of practical work.

In the year 1818 Thenard discovered the combination of hydrogen and oxygen, which he named peroxide of hydrogen; and he lived long enough to conduct a series of experiments which absolutely established its valuable bleaching qualities. There seems to have been no successor to this talented Frenchman. Since his death, a spasmodic interest has been evinced by chemists, but the prevailing idea has been, and even to-day is, that for special classes of work this agent might possibly be employed, but that it was entirely too expensive for general practical use. It is doubtful, however, if any agent exists which comes so near perfection for general bleaching as this same peroxide of hydrogen, which for the past half century has rested in what may be termed a state of "innocuous desuetude."

The bleaching qualities of hydrogen peroxide depend entirely upon the quantity of oxygen which it holds in solution. It is the liberation of this oxygen which does the bleaching; it unites with the natural coloring matter of the fiber with which it is brought in contact, oxidizes and destroys it, without attacking the fiber itself. The principle involved is identical with the old linen bleach; then the sun and air produced the result that is here produced by artificial means.

Every housewife knows that repeated washings whiten linen; she may not know just the cause, but she knows the fact. The reason is that the fiber is softened and expanded in the water, and its exposure to the sun causes it to absorb small quantities of oxygen from the air; which, acting on the coloring matter contained in the fiber, causes at each operation a small loss of color, and by repeated ones a very visible increase of whiteness.

This is precisely what occurs in bleaching with peroxide of hydrogen, except that the concentrated oxygen is here held in solution with the water, whereas in the other case it is widely diffused; and in one operation, of a few hours, results are obtained which, by the old methods, took nearly as many months.

The constitution of water is two atoms of hydrogen united with one atom of oxygen, or, chemically expressed, oxide of hydrogen—the formula H_2O. The constitution of this bleaching compound is two atoms of hydrogen united with two atoms of oxygen, or, chemically expressed, peroxide of hydrogen, the formula of which is H_2O_2; the difference being merely this extra atom of oxygen, which is by an intricate process originally extracted from the air. To describe the process of manufacture would be a tedious matter, and it will suffice to state that oxide of barium is made to absorb oxygen from the air, thus converting it into dioxide of barium, which is, in turn, in combination with water, forced to yield up its oxygen, thereby forming peroxide of hydrogen. The oxygen of this peroxide solution is set free on contact with certain organic bodies, and if it should all be evolved the solution would, in turn, be converted into ordinary water, or, chemically expressed,

H_2O_2	—	O	=	H_2O
Peroxide of Hydrogen,		Oxygen,		Water

It matters little whether this oxygen is set free by contact with fibrous matter like wool, cotton, hair, etc., or by introducing certain chemicals; the result would be the same.

The value of peroxide of hydrogen is here demonstrated to a remarkable degree. The oxygen of the solution, being very slowly set free, penetrates in all directions, and either unites with some matter for which it has great affinity or escapes into the air. Natural coloring matter, as found in fibrous material, seems to possess a remarkable affinity for oxygen, and on the release of the oxygen from the solution, it unites with this coloring matter, destroying its color at the same time that it is changing its character. The fiber is not attacked, because of the greater affinity of the oxygen for the pigments which constitute the color. After the operation there can be nothing left in the fiber, for the oxygen, if it does not expend itself by uniting with the coloring matter of the material to be bleached, simply escapes into the air as gas; there can also be no after-effect when the goods are finished.

It is well known that in the process of wool bleaching with sulphur, certain chemical action takes place long after the goods are finished, and frequently after they are on the market. All dyers further know that goods bleached with sulphur do not take dyestuff well. Cotton dyers also know how well cotton that is bleached with lime, or its combinations, can be dyed, and how much they are tendered. And why is this so? Because each of these bleaching agents leaves traces in the fiber, no matter how carefully they may be washed, which, after a longer or shorter period, undergo certain chemical changes, of a more or less violent character, but always to the detriment of the goods.

If the brown or black wool upon the back of a live sheep or the hair on a goat be carefully washed to remove the grease, it can be bleached with peroxide of hydrogen without injury either to the fiber or the animal. The life of the wool or hair is not in the least interfered with, and it will continue to grow with its natural color.

The writer has seen workmen, employed in the manufacture of peroxide of hydrogen, with half a dozen shades of hair—doubtless from touching with their wet hands; but the life of the hair was not at all assailed. On the contrary, those particular men all had very thick hair.

This is a very important point in favor of the peroxide of hydrogen bleach; the harsh feeling so often met with in sulphur-bleached wool is entirely absent in wool bleached with this agent, the staple being as vigorous and as lively as when it comes from the washing machine.

It would seem that there could be no question whether peroxide of hydrogen is the ideal bleach; its advantages are so numerous and its defects so few. Bleached goods take dyestuffs equally as well as the unbleached—the clear white body must of necessity give brighter and clearer results; the colors are faster, because the natural pigments are extracted and the fiber is in better condition to unite with and absorb dyestuff. The natural color is not simply covered with a coating of finely divided white foreign matter, but is actually destroyed and discharged; and, as there is no foreign matter left in the fiber, there can be no further chemical action. The fiber is in no case injured, because living matter can be bleached without interfering with its growth.

The kind of material that can be bleached is only limited by nature. Ivory or jute, human hair or linen, bone or silk, cotton or wool, it matters little which, they can all be bleached. Some substances are harder to bleach than others. The different coloring matters may be so constituted that they will resist the action of the oxygen in varying degrees, and the darker the color is, the more oxygen it will require to destroy it; but it is safe to say that all natural colored vegetable or animal matter can be bleached.

European manufacturers have for some time been aware of the value of this bleaching agent, and it has been adopted almost universally. Some go so far as to give a partial bleach to goods intended for dark colors, claiming that the advantages gained in the finished material more than compensate for the increased cost. It is also a fact that many classes of textiles are made of mixed stock which a few years ago it would have been impossible to use.

The advances made in the manufacture of peroxide of hydrogen are almost identical with those made in the perfecting of chloride of lime and the alkalies; and it is now possible to produce it at such a price that the cost of bleaching is little, if any, more than with present methods. Practical use has shown a cost which is surprisingly low; and if the damage done to machinery and metal fixings, where lime and acid are now employed, and in some localities the increased rate of insurance and items of a like character are taken into consideration, there can be no doubt that the bugbear of cost could no longer be raised.—Edward Prag, in the Dyers' Trade Journal.

ESTIMATION OF PARAFFINS IN CRUDE ANTHRACENE.

A NEW method has recently been devised for the estimation of paraffins in crude anthracene by Herrn Heusler and Herde.

The rationale of the process depends on the complete solubility of the whole of the crude anthracene with the exception of the paraffin in fuming nitric acid (HNO_3). According to a number of experiments which have been conducted in order to test the reliability of this new method for adoption by tar distillers' and dyers' chemists, the results are in most satisfactory accordance with those obtained by the old method hitherto employed. In addition it is contended that the estimation of the paraffin can be more conveniently and speedily executed.

The following is the method of procedure as advised by the authors: Not less than 2 grammes of the crude anthracene are weighed off into a small flask of about 150 cb. c. capacity, which is surrounded with ice water. Fuming nitric acid is then introduced drop by drop, in the proportion of 25 cb. c. to every 2 grammes of crude anthracene. When all the nitric acid has been added as directed, a complete solution of the anthracene will have been obtained. The flask is then warmed on the water bath for a short while until all the paraffin is melted. After cooling, the paraffin can be collected on a small asbestos filter, where it is washed with fuming nitric acid until a drop of the filtrate gives no turbidity with water. A thorough washing with water is next given, till the filtrate no longer gives an acid reaction with blue litmus paper. A fresh receiver is then placed under the funnel, the paraffin washed through into it with alcohol, and finally with ether, which has been slightly warmed.

The alcoholic solution is then transferred to a weighed porcelain basin, and evaporated on the water bath, after which the ethereal solution is added, and ether allowed to evaporate in a warm place. The paraffin which is left is dried for half an hour at a temperature of 105° C. to 110° C., allowed to cool in the desiccator, and finally weighed.

ABRUPT emission of waste steam up the chimney causes the cough or puff of a railway engine. When moving slowly the coughs can, of course, be heard following each other quite distinctly, but when speed is put on the puffs come out one after the other much more rapidly, and when eighteen coughs a second are produced they cannot be separately distinguished by the ear. A locomotive running at the rate of nearly seventy miles an hour gives out twenty puffs of steam every second—that is, ten for each of its two cylinders.

[Continued from SUPPLEMENT, No. 1014, page 16208.]

RECENT ADVANCES IN ELECTRO-CHEMISTRY.*

By JOSEPH W. RICHARDS, A.C., Ph.D.

Carborundum.—This is the name of a recent product of the electric furnace, a silicon carbide, having the composition CSi. Mr. E. G. Acheson † first made it by heating fine carbon and clay between carbon poles in an electric furnace. Thinking that it was a compound of alumina and carbon, he named it accordingly, in allusion to its presumed resemblance to a combination of carbon and corundum. It is a green crystalline compound, and so extremely hard that it has found wide practical application as an abrasive material. Made up into wheels it is found to have better wearing qualities than emery, and the fine dust can be used for polishing precious stones and even the diamond. The Carborundum Company, of Monongahela City, Pa., produced, in 1893, 15,000 pounds of this material, which sold at $4 per pound. During 1894, a German works was started at Iserlohn.

The method of manufacture is briefly as follows. A mixture made in the proportions:

	Parts.
Sand	182
Coke	146
Salt	72

This will produce 100 parts of carborundum.

Two hundred pounds of the mixture are placed in a fire brick-lined cavity, 6 feet long, 18 inches wide and 12 inches deep. Four carbon electrodes at each end supply the current, and a core of carbon dust starts the arc from one end to the other. The current from a 100 horse power dynamo is sent through for eight hours, three charges being run per day. The silicon carbide found between the electrodes is treated seven days with dilute sulphuric acid to remove iron, and is then ready for sorting and working into wheels, etc. The company enlarged its works in 1894, and is doing a flourishing business, the product having gained the reputation of being the best abrasive known.

Calcium Carbide.—This is another recent product of the electric furnace. T. M. Willson, ‡ of Spray, N. C., in the course of experiments to produce alloys of calcium and aluminum, succeeded in forming a black, brittle, fusible substance, which chemical analysis showed to be calcium carbide (CaC_2). From a mixture of—

	Pounds.
Burnt lime	2,000
Fine coal dust	1,200

and with the use of 180 electric horse power for twelve hours, Mr. Willson claims to be able to produce 2,000 pounds of calcium carbide, at a cost approximating $20. This substance promises to be of great industrial value from the curious reaction it gives with water:

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$

In other words, it is converted into calcium hydrate, giving off acetylene gas in the proportion of 100 parts of gas to 247 calcium carbide, which would mean approximately 10,000 cubic feet of gas per ton of carbide. This gas has the highest illuminating power of any known hydrocarbon, and, when mixed with half its volume of air, can be burned without smoking, giving a flame five or six times as brilliant as ordinary illuminating gas. It has been claimed that this gas, equal in illuminating power to coal gas of 25 candle power per five foot burner, can be made at a cost of 30 cents per 1,000 cubic feet.§ Other and more important uses for this gas may be found in the field of technical chemistry. For example: by passing electric sparks through a mixture of acetylene and nitrogen, hydrocyanic acid is formed, from which cyanides can be made. By heating in a sealed tube, it passes into benzene. By an indirect process it can be made to yield alcohol. The difficulties which the projectors are now seeking to overcome are the danger of explosion of the gas mixed with air and the decomposition of the carbide by the action of the atmospheric moisture.

Cleaning Metallic Surfaces.—The operation of pickling has been improved by the use of electrolysis. The articles are immersed in dilute sulphuric acid opposite to a negative pole of carbon or wire gauze, electro-plated with silver and preferably covered with platinum black. On connecting electrically the articles with these poles, by a wire outside the bath, gas is disengaged at the silvered surfaces, while the articles are rapidly and uniformly corroded. If a little nitric or chromic acid be added to the bath as a depolarizer, no offensive odors are given off. Another method is to use as a bath a salt of the metal to be pickled and an external electric current. The articles to be pickled being used as anodes, they are rapidly corroded, the metal being deposited on suitable cathodes, while the bath remains constant. This method has the great advantage of dispensing with the use of fresh acid, and will doubtless come into extensive use.

THE METALS.

Aluminum.—No very recent improvements have been made in the electrical processes for extracting this new metal. It is now made exclusively by the electrolysis of alumina dissolved in a bath of the fused fluorides of aluminum and sodium, the dissolved alumina being decomposed while the solvent salts are unaffected by the current. The principal works are those at the Rhine Falls, in Switzerland, using 4,000 horse power, and making three tons daily by Heroult's process, and the Pittsburg Reduction Company, making one ton daily by Hall's process. The latter company will presently start a new and much larger plant at Niagara Falls, beginning with a daily output of two tons, which within a year may be increased to four tons.

The total output of aluminum in the world in 1894 was 1,020 metric tons. The present selling price is thirty-five cents per pound in Europe and fifty cents in the United States. The Swiss works intend extending to 15,000 horse power within the next five years, when the European price will probably fall to twenty-five cents per pound. The wonderful development of the electro-metallurgy of aluminum is one of the most striking achievements of modern electrochemical science.

* A lecture delivered before the Franklin Institute, February 1, 1895.—From the Journal of the Institute.

† Journal of the Franklin Institute, 136, 194.

‡ Engineering and Mining Journal, Dec. 15, 1894; this Journal, 139, 321.

§ Mr. Willson's present claims are much more radical even than this.—ED. J. F. I. See this Journal, 139, 321 et seq.

In the utilization of this metal, Mr. J. D. Darling, of Philadelphia, has gained celebrity by electroplating 100,000 square feet of ornamental iron work on the tower of the new public buildings of that city. The question as to whether aluminum could be electroplated on another metal at all was a doubtful one until Mr. Darling began work on this tour de force. The chemical composition of the bath used is kept as a trade secret. The columns, etc., to be plated are first coated heavily with copper, in the ordinary way, and then coated over with aluminum one-sixteenth of an inch thick. This last operation takes seventy-two hours, the current used averaging ten amperes per square foot of anode surface, and seventeen amperes at the depositing surface, an electromotive force of eight to ten volts being used to each bath. Specimens of the work which I have seen are very well done, and reflect great credit on the skill of this Philadelphia electro-metallurgist.

Antimony and Arsenic.—Electrolytic processes for reducing these metals from their ores have been devised, but I cannot say whether they are in practical operation. Siemens and Halske* treat the natural sulphides of these metals with solutions of alkaline sulphide, in which they are soluble, forming alkaline double sulphides. The solution is then electrolyzed, separating out the arsenic or antimony and leaving an alkaline sulphhydrate in solution. The reactions would be

$$\text{(Solution) } Sb_2S_3 + 6NaHS = Sb_2S_3 3Na_2S + 3H_2S.$$
$$\text{(Decomposition) } Sb_2S_3 3Na_2S + 3H_2O = Sb_2 + 6NaHS + 3O.$$

Diaphragms separate the vat into anode and cathode cells, the positive poles being of carbon or platinum.

Chromium.—Pure, metallic chromium is now obtainable in large quantities. It is made by the electrolytic process of Placet and Bonnet.† To a dilute solution of a chromium salt are added the sulphates or chlorides of the alkalies or alkaline earths; also, certain organic substances, such as gum arabic or dextrin. The solution is one-fifth saturated with the chromium salt and four-fifths with the other substances. The solution is warmed; a cathode much smaller than the anode is used to give great current density at the depositing surface without requiring excessive power, and a current at thirty to forty volts is used for decomposition.

To make chromium alloys, the salt of the alloying metal is added to the solution in about equal quantity to the chromium salt. With a low voltage, only the alloying metal (as iron) separates; with higher voltages increasing amounts of chromium are deposited with the other metal, so that any desired proportions can be obtained. Or, the alloying metal may be first deposited alone by using a low voltage, then the desired quantity of chromium by a higher voltage, and the whole plate melted down to form the alloy.

Manganese, Tungsten, Chromium.—Moissan ‡ has found the oxides of all these metals easily reducible in the electric furnace. A current of 300 amperes at 60 volts, passed for six minutes through a mixture of manganese oxide and carbon, gave 100 to 120 grammes of manganese, containing from 6 to 14 per cent. of carbon, according to the excess of carbon present. The same current, passed for ten minutes through a mixture of chromium oxide and carbon, gave 100 to 110 grammes of chromium containing from 8·6 to 11·9 per cent. of carbon. By mixing this chromium carbide with fresh chromium oxide and heating it again in the furnace, the carbon was eliminated and pure chromium was obtained. Tungstic acid in the same manner gives tungstic carbide, with 17 to 19 per cent. of carbon, which can also be reduced to pure tungsten by heating with more tungstic oxide.

Copper.—The electrolytic refining of copper is now carried on commercially on an immense scale. There are two single plants in the United States, at Baltimore, Md., and Butte, Montana, which have a daily capacity of fifty tons each. In 1894, over 50,000 tons of copper were refined in the United States, and the time is probably not far distant when the whole copper production will be electrolytically refined. The cost of refining at the new Anaconda plant, at Butte, Montana, under the direction of Mr. Thofehrn, is said to be only 0·6 cent per pound. An innovation in the practice of these works is the removal of ferrous sulphate from the solution by warming it and blowing air through, when the iron precipitates as basic sulphate. It is stated that Lake Superior copper is not of as good quality as formerly, because of poorer ores and closer working, and that the Calumet and Hecla Company contemplates changing its smelting plant at Buffalo into an electrolytic plant located at Niagara Falls, where power can be rented at $7 to $10 per horse power per year. The copper thus refined will command a higher price, and, at the same time, the silver contained in it can be extracted.

Gold.—Munster § claims that he has found in the sea water of Christiana Fjord twenty milligrammes of silver and six milligrammes of gold to every 100 cubic meters water. He proposes to extract these by immersing galvanized iron electrodes in the channel, and passing through them an electric current of feeble tension.

In the cyanide process of treating gold ores, the gold is dissolved in a solution of potassium cyanide. To extract it from this solution, an electrolytic process has been found advantageous. The electrodes must have a large surface; lead is used for the cathodes and iron for anodes; carbon anodes disintegrate too quickly. To precipitate the metal from 100 tons of cyanide solution carrying five dwts. of gold per ton in twenty-four hours, requires 10,000 square feet of cathode surface, and a current of 600 amperes at four volts tension. The iron plates form Prussian blue, but last a long time. The anodes are placed vertically, and are covered with canvas to keep the Prussian blue out of the liquid. The lead sheets stand between, with 1·5 inch space between the electrodes. The electrolyzing boxes are covered and kept locked, being opened once a month, when the lead plates are lifted out and melted down. They carry two to twelve per cent. of gold, and are cupeled. The expenses are three shillings per ton of liquor treated, and on a large scale it can be reduced to 2·5 shillings, whereas, the ordinary method of precipitating by zinc costs four shillings.*

* German patent No. 67,973.

† The Mineral Industry, 1893, 560.

‡ Comptes Rendus, 116, 349, 1,225.

§ Engineering and Mining Journal, 58, 570.

Parting Gold and Silver.—The Moebius† electrolytic process is used by the Pennsylvania Lead Company, near Pittsburg, and by the St. Louis Smelting Company. The alloy of gold and silver is cast into anodes, and used in a ten per cent. solution of nitric acid. A current of 1·4 volts per cell is used, and a current density of twenty-six amperes per square foot. The plant at Pittsburg consists of forty-two cells, run by a current of 180 amperes by sixty volts, there being seven square feet of anode surface in each cell. The output is 20,000 ounces of silver per day. The anodes contain 987 parts silver, 6·3 parts gold, 6·7 parts copper. The deposited silver contains a little copper. The slimes are melted down with silica and borax to an alloy averaging 650 parts of silver and 300 parts of gold, the remainder being lead and copper. This rich alloy is melted with more pure silver and parted with nitric acid. It is said that this process is cheaper than the ordinary parting process, but one would hardly judge so from the description given.

Lithium.—Guntz ‡ mixes anhydrous lithium chloride with an equal weight of potassium chloride, the mixture melting at 450° C., and electrolyzes it with carbon anodes eight millimeters in diameter, and iron cathodes three to four millimeters in diameter, inclosed in a glass tube, twenty millimeters inside diameter. By keeping the temperature low and using a current of ten volts and twenty amperes, the lithium is separated and collects in the glass tube. It contains one to two per cent. of potassium, but it is pure enough for most purposes for which it may be used.

Magnesium.—This metal is now made only by electrolysis, the sodium method having been entirely displaced. The principal works are those of the Aluminium und Magnesium Fabrik, at Hemelingen, near Bremen. The process consists in the electrolysis of the fused double chloride of potassium and magnesium reducing gases being introduced under the cover of the vessel to prevent the magnesium from firing. Recently, an alloy, called magnesium zinc, has been introduced into commerce as a substitute for pure magnesium. It is an alloy of about sixty-two per cent. magnesium, twenty-six per cent. zinc, and twelve per cent. of iron. It is very brittle, can easily be reduced to powder, and is said to answer quite as well as pure magnesium in pyrotechny and photography, while it costs much less. The method of manufacture is to electrolyze the above named fused salt in a crucible with molten zinc at the bottom for a cathode. In this way an alloy of magnesium with thirty per cent. of zinc is obtained. Some ferrous chloride is then stirred into the bath, which is at once reduced by the alloy, and the iron thus introduced.

Sodium.—Metallic sodium is now made only by electrolysis, and principally by Castner's process.§ His works at Oldbury, England, use 1,000 horse power, and have an output of from five to six tons weekly. A similar plant has recently been erected near Frankfort, Germany. The sodium produced is used either to make sodium peroxide for bleaching purposes, or in the manufacture of organic salts and dyes. The making of antipyrine by Dr. Knorr's patented process involves the use of sodium.

The process consists in the electrolysis of fused caustic soda, kept at a constant temperature of 313° C., in specially constructed cells, each cell taking 1,000 amperes of current and an electromotive force of only 4 to 4·5 volts. The efficiency is about eighty per cent. By keeping the temperature not more than 30° above the melting point of the soda, the electrical resistance is low, the operation proceeds uniformly and the sodium runs off from the top of the bath in a melted state. This last point is of especial advantage, as the distillation and condensation of the sodium, with all their attendant losses and dangers, are entirely avoided.

J.D. Darling and H.C. Forrest, of Philadelphia, propose ‖ to electrolyze sodium nitrate in a similar manner at a gentle heat, obtaining the sodium melted, and, at the same time, passing the vapors produced at the anodes through water in Wolff bottles, and producing nitric acid. I have not yet learned whether this process is being practiced commercially.

Zinc.—Cassel and Kjellin, of Stockholm,¶ propose the following process of extracting zinc from its sulphide ores. The ore is roasted as far as possible to soluble zinc sulphate, which is leached out. The electrolyzing vessel has a porous partition; around an iron anode is placed a solution of sulphate of iron, while the zinc sulphate solution surrounds the cathode. On passing the current, zinc is deposited from the latter solution, while its equivalent quantity of acid is separated at the iron anode and dissolves it to sulphate. The electromotive force of decomposition, under these circumstances, is the difference between that required to decompose zinc sulphate and that of the iron sulphate, or about one-third of a volt, thus allowing the separation of zinc without decomposing the water of the solution. The process is very pretty in theory, but the porous partitions will be likely to give trouble in practical working, and the question of the cost of the iron used and the market for the copperas produced form large factors in deciding the economy of the process.

Heinzerling proposes to roast zinc ores completely to oxide, and dissolve this out by a concentrated solution of magnesium chloride. This solution is then electrolyzed, the zinc separated out, and the magnesium chloride solution used over again. Solution of the zinc oxide is effected hot, under two or three atmospheres pressure. A current of 200 amperes per square meter is used for electrolysis, while the solution is kept as cold as possible.

Galvanizing sheet iron by electricity has again been

* Elektrochemische Zeitschrift, March, 1895.

† Journal of the American Chemical Society, January, 1894.

‡ Comptes Rendus, 1893, 732.

§ Scientific American Supplement, July 7, 1894, 15485.

‖ English patent, No. 5,808 (March 20, 1894).

¶ German patent, No. 67,303 (1893).

tried, this time at the works of Watson, Laidlaw & Company, Glasgow, Scotland. The depositing bath contains zinc oxide dissolved in caustic potash, kept warm, and the sheets are kept in motion. The metal is deposited for five to twenty minutes, at the rate of 34 to 134 grammes per square meter per minute.

Your lecturer has conducted an extensive series of experiments in refining impure zinc by electrolysis. By using a current density of 100 amperes per square meter, at 1·3 volts tension per bath, and keeping the solution agitated by mechanical means, thick deposits of zinc of exceptional purity can thus be obtained. The accumulation of iron in the solution is prevented by blowing air through it continually, which oxidizes and precipitates the iron as basic sulphate, that can be separated by filtration. There is considerable loss in melting down the zinc sheets to ingot shape; but notwithstanding this, the process could be operated commercially but for the very low price which zinc has reached within the last few years, the margin for profit being less than in refining copper, while the expenses are greater.

VACCINATION FOR DIPHTHERIA.

In the accompanying engraving, reproduced from a painting by Andre Brouillet, the artist has not endeavored to dramatize an action, which is sufficiently eloquent by itself, but to show us a page of medical history in its rigorous exactitude. We are at the Trousseau Hospital.

At the head of the bed, upon which he is leaning, stands Dr. Roux watching the application of his treatment of croup by the injection of serum into a little girl whose somewhat brightened eyes are fixed upon Dr. Moizard, the operator. The latter is assisted by Madam Gigot, the head nurse, who holds the child, whose arms are covered by the rolled-up shirt. Behind him stands Dr. Perregaux, the house surgeon, and at his right are Drs. Martin and Chaillon, colaborers of Dr. Roux at the Pasteur Institute. A second nurse holds the legs of the young patient. At the foot of the bed are seen a few playthings that some maternal hand has placed there to cheer up the little one. The bottle of serum stands upon a shelf fixed to the wall. To the right of Dr. Chaillon advances a nurse holding in her hands the glass bowl containing the sublimate that has been used for washing that part of the body in which the injection is made, and who is making her way toward a rolling night table. At the end of the ward we see another nurse, who is giving a child a drink. Through the high windows looking out upon the gardens and faubourg Saint Antoine enter the rays of a cheerful sun that illuminates a scene in which the inquietude of the first moment will soon give way to hope and joy. Science has finally vanquished the merciless disease.

Our readers probably know that diphtheria is produced by a microbe that secretes a poison which infects the blood. Submitted to a special treatment in a culture bouillon, this bacillus furnishes diphtheric toxine, which being injected into a horse (the animal that gives the greatest quantity of antidiphtheric serum), inoculates the latter, and consequently permits of rendering refractory to the disease any one who has been vaccinated with the antidiphtheric serum taken from the animal that has become serogenous.

The toxine is prepared at the Pasteur Institute, under the direction of Dr. Martin, and sent to the three services annexed to the establishment, viz., the abattoirs of Grenelle, where thirty horses are placed under the care of Mr. Carre; Alfort, where a dozen horses are specially treated by Dr. Nocard; and Garches, the stables of which comprise no less than eighty-four horses, and where a new stable is building that will accommodate sixty-eight. It is here, moreover, that will be concentrated the manufacture of the precious serum when the new structures that are erecting shall permit of giving a greater extension to the different services. Here there will be a special cellar for the storage of the serum, an elevator, a washing room comprising the most recent improvements, etc. It is to Garches, therefore, that we shall take the reader in asking him to follow us in the visit that we have made in company with the young and amiable veterinary surgeon, Dr. Prevot, who is in charge of this important branch.

The establishment of Garches is situated in the middle of a twenty acre park inclosed in the old imperial domain of Villeneuve l'Etang, which skirts the railway at a few minutes' walk from the station. It is surrounded by walls, and there is nothing to attract attention to it externally. A few goats, evidences of the first experiments, browse tranquilly in the park, through which roams a dog which likewise is worthy of the name of subject. This unfortunate, which, however, does not appear to be any longer ailing, has undergone the operation of trepanning and inoculation of the virus of rabies three times. The present structure, which is very simple in appearance, consists of a main building flanked by two wings and provided in the center with a pavilion that contains the apartment of Mr. Pasteur.

To the right and left are the quarters of Drs. Martin and Prevot, then comes a small hall used for receptions, and finally the different rooms used for laboratories. In the large latticed sheds contiguous to the building are kept eight hundred guinea pigs that serve for experimenting upon with the serum obtained at every bleeding of a horse.

Dr. Prevot estimates that the number of these modest auxiliaries that it will be necessary to have at one's disposal for the next winter will be five thousand. Entering the stables, we find in the first place that the horses, which present a fine appearance, suffer in nowise from the regimen to which they are subjected. For each one of them there is provided a memorandum book containing notes relative to his origin, temperament and ailments. Moreover, a slate suspended above each animal indicates the latter's temperature as taken every day, the date of the preceding bleeding and of the following, etc. These horses are for the most part derived from the army. Others, however, have been presented to the establishment and have won other laurels before those that their new and glorious mission has in reserve for them—such for example as Saint Claude, a former winner of the grand prize of Auteuil, and who peacefully eats his food near Coquet, a horse formerly owned by Marshal Canrobert.

The horses are not utilized before the age of eight or nine years. The cavalry of the Pasteur Institute already embraces veterans which, vaccinated as long as four years ago, have given up from four to five hundred quarts of blood. The establishment of Garches, in which so many experiments are made, has been furnishing serum since the month of October, 1894, but the vaccination service has operated regularly and uninterruptedly only since December 1. The operating hall of the building now constructing has been provided with a trave, an ingenious apparatus that permits two men to overcome the most obstinate horse.

Every horse purchased costs about a thousand francs, and requires a like sum for his annual maintenance. As soon as he is admitted to Garches he is subjected to the test of malleine, one injection of which suffices to demonstrate whether or not he is affected with glanders. His good constitution having been proved, the new boarder is injected with diphtheric toxine in quantities that progressively increase and go from 0·013 of a fluid ounce diluted with Gram liquor to 7·5 fluid ounces of pure liquor. The vaccination is effected between the shoulder and the head. As a general thing, the animal is not completely inoculated until the end of two or three months. Bled from the jugular vein, he then furnishes six quarts of blood every twenty-one days.

Every bleeding is followed by a revaccination in order to preserve the same degree of indispensable efficacy in the blood. The bleedings take place on Mondays and Wednesdays. Practiced upon twenty-five horses, on an average, they permit of collecting every week from two hundred to two hundred and fifty quarts, producing half that quantity of serum. The liquid thus obtained is poured into jars wherein the separation of the serum and clots of blood takes place, the serum floating on the top. The serum, decanted into reservoirs of a capacity of from eight to ten quarts, is distributed through gagers containing from 0·3 to 0·6 of a fluid ounce, and thence passes into the bottles that are to be delivered for consumption. Two days and a half suffice to reach this result, but every bottle remains submitted to observation for several days before being delivered. The preparation of the serum at Garches is confided to six persons—three men and three women. The men are employed, among other things, in the sterilization of the bottles, which are arranged in a digester submitted to a humid temperature (steam) of 120°. The women fill and cap the bottles. One woman can fill mechanically as many as three hundred 0·3 ounce bottles an hour, or two hundred 0·6 ounce ones, say, for the two capacities, about two thousand bottles a day. The figure of three thousand deliveries might easily be reached. The establishment has already furnished more than a hundred and fifty thousand bottles, out of which not more than ten have been rejected after being submitted to observation. The bottles of serum, after being corked and capped, are sent in cases of from three to four thousand to the annex of the Pasteur Institute, 18 Dutot Street, where is located the sales room of the antidiphtheric serum, and where they are labeled and stamped, wrapped in a sheet of directions, and finally inclosed in wooden boxes.

A few general indications upon the use of the serum will be in place here. The serum will preserve its properties if kept in a place whose temperature is somewhat elevated and protected from light, and if the bottle be not taken out of the case in which it is inclosed. Above 50°, the serum becomes inactive. Its preservation is assured by the addition of a small quantity of camphor to it. Employed in a dose of 0·15 fluid ounce, it gives a transient immunity of from four to six weeks, which is very appreciable in times of an epidemic of diphtheria. Injected in sufficient quantity, the serum will cure the disease, provided it has not reached too advanced a stage. The dose to be employed varies according to the age of the patient, the moment

VACCINATION FOR DIPHTHERIA AT THE TROUSSEAU HOSPITAL, PARIS.

of the intervention and the intensity of the disease. Before injecting the serum, it is necessary to be certain that it is limpid. A very slight precipitate at the bottom of the bottle does not indicate an alteration. After an injection there is frequently observed an eruption resembling urticaria, which disappears without causing any notable uncomfortableness. The last statistics published show a hundred and forty cures out of a hundred and fifty cases of diphtheria treated at the Trousseau Hospital. The specter of diphtheria will still be able to stalk around the cradle, but it has ceased to be terrible, and the fright that it causes will diminish every day.—Le Magasin Pittoresque.

ANTI-DIPHTHERIC SERUM.

THE Journal de Pharmacie announces that the Institut Pasteur now supplies anti-diphtheric serum to pharmacists, who alone have the right to supply it. It is delivered in bottles of two sizes, at 5 francs and 2½ francs respectively, and these are to be retailed to the public at 6 francs and 3 francs each. Hospitals and indigent persons are supplied without charge. In the instructions supplied with the serum, it is directed that the bottles should be kept at a low temperature, in a dark place, without removal from the cases in which they are sent out. The serum becomes inactive above 50°, and to insure its preservation a very small quantity of camphor has been added. Used in doses of 5 c.c. it is said to secure immunity against diphtheria for four to six weeks, and its preventive power is such that the injection of a quantity equal to 1/50,000 of the body weight of a guinea pig will enable it to withstand the effects of a fatal dose of a virulent culture of the toxine of diphtheria.

WHY WE LAUGH.*

PEOPLE laugh under the most diverse circumstances. A pun, a snore heard in a solemn assembly, the artlessness of a child, a dog which enters church during the services, a repartee, a drunkard who reels, a parody, the robe of an actress which is torn by a nail in the floor, an old style costume, an orator's slip of the tongue, the caper of a clown—these are a few of the instances which occur to my memory. It is my wish in this study to show that they all resemble one another, and also to find in all the cases the common element which excites laughter.

It is hardly necessary to indicate the common opinion that laughter is caused by joy. But it is evident that joy does not always excite it—there are grave joys. It is also plain that people often laugh without being joyous. Without doubt, joy disposes to laughter, but it does not produce it. One of the most common opinions is, that it is caused by the unusual, the odd, by that which is not in accord with our habits of mind, by something which breaks the familiar course of things. This is the theory adopted by Darwin. We shall admit at once that whatever is odd is often ludicrous. We will go further and say that, doubtless there is not a word, an act, a situation, an attitude, which is truly laughable which is not unusual. But it is equally true that the unusual does not always cause laughter. There are events contrary to the normal order which are the very opposite of amusing.

Another theory very widespread is that of contrast. It is incontestable that many contrasts are mirth provoking, but as many others are not. Another very interesting theory is the one proposed by Bain. He calls the real cause of laughter degradation. When we see in a grand personage the infirmities of human nature; when under very imposing circumstances some commonplace event suddenly calls us back to earth; when the littlenesses of great things and of great men are suddenly revealed to us, the degradation stirs us to laughter. That this solution is in accord with many facts it is impossible to deny. However, in this case also there frequently occurs the spectacle of a degradation entirely lacking in ludicrous features.

Let us now try to find the true cause, the condition which when produced always produces laughter, which when suppressed always suppresses laughter. Who has not been amused at an attempt to break in an unlocked door? A man gathers all his strength, contracts his muscles, draws up his face, and braces himself to force open the door. We know that the door is not fastened, and we laugh. Circus clowns excite laughter by analogous means. For instance, they put forth an immense effort to lift from the ground an enormous cannon ball. But we know the ball is made of pasteboard and is as light as a feather. What is it that really takes place within us under such circumstances? It is evident that the action appears to us at first odd. But at the same instant in which we see that the act is absurd a rapid reflection makes it also seem very natural. We think that our man believes the door is locked. We think that in the eyes of the clown the ball is a true ball. The effort which they make then is a natural one; we would have done the same. It is then that we laugh.

Thus, the same thing appears to us both surprising and familiar. In this condition rests the spirit of laughter. The law of laughter, then, we think can be formulated thus: that which causes laughter is that which is at once, from one point of view, absurd and from another natural. A very common observation will prove to us that it is only necessary to suppress one point of view in order to suppress laughter. It often happens that the impulse to laugh does not follow until some instants after the exciting cause has transpired. There was no laughter immediately because the double bearing of the case was not perceived; there was only perplexity regarding it. But as soon as the second meaning burst upon the mind, all was clear and laughter followed.

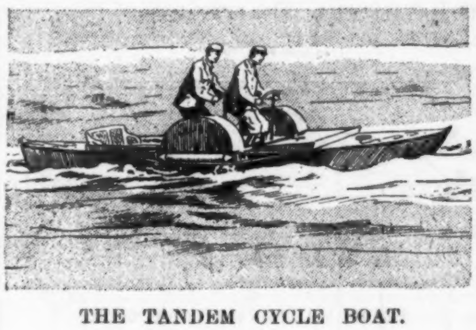
Of the circumstances favoring laughter the principal are, the physical well-being, childhood and youth, the consciousness of success or victory which one has just gained, or of a danger which one has just escaped. Physical well being disposes to laughter because it renders the mind keener and more active. We see and comprehend more quickly both the unusual and the familiar. Children and youth laugh more than older people because their fresher minds find more unusual things. Again, during youth, the mind, more supple, more rapid, perceives more rapidly the bizarre, and, under it, the familiar. Women generally laugh more than men; it is because they have minds nearly as supple and as clear as those of young people. Victory disposes so strongly to laughter that some philosophers, Hobbes among them, have sought in it the very cause of the laughter. But it is not to be found there. That which is true is, that success stimulates the mind, gives it a sort of intoxication. Then keenly excited, we see more keenly, and grasp situations more readily.

Thus the more an object appears at the same time strange and familiar, the more we laugh. The less we are capable of perceiving these two sides, the less we laugh. What, then, is the psychological law of laughter? Our mind is a force which has a unique office, its task is to enter all new objects into known categories. When an object can find a place in no category, it entirely escapes our thought. Whenever an object finds a place at once in two categories which are exclusive the one to the other, it shocks our thought. When an object newly and regularly enters a category, we experience the calm enjoyment of thought, of knowledge; it is rational. When a new object presents itself, and according to one view is classed in the list of the absurd, and from another view finds its place in a category marked familiar, thought experiences a spasmodic shock—it is laughter.

* M. Camille Melinand, in the Revue des Deux Mondes, Paris. Translated for the Chautauquan. Condensed for Public Opinion.

ACROSS THE CHANNEL ON WHEELS.

A CORRESPONDENT sends a sketch relating to the recent crossing of the English Channel on a tandem cycle boat by Mr. John Ruck, of Chislehurst, Kent, accompanied by Mr. R. E. Wicker, of St. Bartholomew's Hospital, London. Mr. Ruck and his companion put into Margate Harbor on Saturday afternoon, having made the journey thither on the new boat from Woolwich. The same afternoon they started for Dover, arriving there in the evening and starting on their voyage across the channel at eight o'clock on Sunday morning. Perfect weather favored the adventure, and the boat reached Calais Harbor safely at quarter past three. The Securitas, as Mr. Ruck's new boat is called, is twenty-four feet long, and is built on gig lines, with a deck fore and aft. She has two cylinders, one on each paddle-box, and these help her buoyancy. She is fitted with tandem cycle fittings, and with her



THE TANDEM CYCLE BOAT.

patent eccentric paddles will, it is said, attain a speed of over seven miles an hour.—Daily Graphic, London.

VILLAGE IMPROVEMENT SOCIETIES.

By JNO. GILMER SPEED.

I AM frequently asked to give counsel as to the best way to start a village improvement society. As villages differ from one another almost as much as persons, it is not always easy to answer this question, unless tolerably full information as to the needs of the village and the characteristics of the inhabitants come along with the inquiry. An upland village, where the drainage is not at all difficult, but where roads and sidewalks are needed, is one problem; and a lowland village, where the drinking water is likely to become impregnated with sewage, is quite different. So the persons who conceive the idea of starting a village improvement society would do very well, before beginning any agitation of the subject, to have some tolerably clear ideas as to what general lines of work should be followed. It is easy for such public spirited villagers to get what is expert advice, for very many villages have been improved, and any intelligent leader in the movement in his own locality could not have failed to gain experience of value. Without such "professional" advice, I suggest that those who have such work in contemplation should visit some "improved" village and see for themselves what has been done, and learn how this was accomplished and how much it cost. With this information the leaders ought to be in a position to formulate a general, though a tentative, plan of operation.

When these improvers begin talking to their neighbors of their plans, they will learn that the average villager is firmly persuaded, from what he has heard and read, that village improvement begins and ends with the tearing down and removal of front fences. Front fences, they will learn, according to the village view of life, signify ownership and preserve the sacredness of privacy. So my advice in the very beginning is that this subject of front fences should be avoided with all possible care. It is more full of peril to the success of a movement than anything else that will be encountered, including the stolid indifference of those who don't want things to be any better than they are. Indifference is passive; the love of a front fence in an old fashioned village, untouched by the magic hand of the improver, is one of the most active passions that can be aroused. By all means, therefore, let the front fences alone until many other things have been attended to.

An improvement society should have in its membership both men and women, old and young. Indeed, if there be in the village an energetic and enthusiastic woman, whose energy and enthusiasm are regulated by wisdom and a capacity for affairs, it would be an excellent thing to secure her as the leader of the movement and later as the president of the society. But the interest of others must also be secured. Do not leave out of the initial consultations the men and women of influence and property, nor yet the gossips and the creatures of fashion. Get representatives of all sets and all factions interested in the very beginning, and avoid any discriminations on social, political, or religious lines. A village improvement society, to accomplish anything worth while, should be an absolutely pure democracy, with a motto like that of the Swiss Confederacy: "One for all, and all for one."

When a group representing all the inhabitants of the village shall have been formed, it is frequently an excellent thing to secure the services of a lecturer who can tell the people of the benefits of village improvement and recite instances of the good results in other places. Then call a public meeting, and not only invite, but urge, all the people in the town to be present to hear the speaker. When he has finished his remarks—and if he be a person of ability he will hardly fail to excite some measure of enthusiasm—a society should be formed then and there, with an initiation fee and yearly dues so low that very few will be deterred from joining on this account. The tentative plans of the society should have been formulated and printed before the meeting, so that copies may be distributed while those present are asked to join. It is of great importance that those who are present should have something to take away with them, something that will prevent them from misunderstanding the purposes of the society and wrongly reporting what has been done and said. It is also of great importance that at this first meeting something quite practical should be decided on. I know nothing better than a "cleaning bee." Get all the men present to engage to give a day in the near future when the whole village shall be cleaned up and put in as good order as possible. The women should organize at the same time to give to these village workers a picnic dinner that day. The work that can be accomplished in such a day as this is immense, and makes a very great showing. The most indifferent person in the village will not fail to see that things look better, and the enthusiastic will probably conclude that, with further effort, their town will soon rival Goldsmith's Auburn, the "loveliest village of the plain." Then, also, such an occasion is pretty sure to give rise to a more neighborly and more friendly feeling, and help to break down those unlovely barriers of reserve which separate villagers more completely even than townfolk are kept apart from one another. Not much money can be secured from fees and dues; so efforts should be made at once to get within the treasury some substantial funds. Entertainments and fairs can be given, or such other steps taken as experience in the locality would warrant. Probably there is not a village in the country which has not sent out into the larger world men who have had abundant success. These men, though all their material interests may now be in the great cities, have not forgotten the old homes of their boyhood. They not only have not forgotten, but it is very seldom that they do not preserve a most tender and kindly interest in the old scenes, the old friends. Now, when a village is to be improved, these men should be informed of what it is proposed to do. I do not recommend that they be besought. I do not believe that much can be had from a man to whom suggestions must be made with indelicate insistence. Let such men be informed; if it be likely that any of them will do anything, the idea will occur to him, and then he will have pleasure in the deed. I do not know of a single village which has been beautified by an improvement society where some man or woman of wealth has not come forward and supplemented the work with generous assistance. Here a library has been given to the village; there a park or playground has been thrown open and improved; and so on.

This reminds me that a village improvement society would do well in the first instance to be incorporated, so that it may acquire property—not that it may go into debt. Debts should be avoided as of fatal consequence. So soon as a society is known to have an empty treasury and to be in debt, it is very likely to begin to lose members. There should be a by-law of each society permitting none others than the executive committee to assume liabilities, and forbidding this committee to contract any debts greater than the money then in the treasury will discharge. But, really, the society can accomplish a great deal without spending money. Now, take the matter of roads. No village can be very highly improved unless the roads through it and in the neighborhood of it be macadamized or otherwise put in good and permanent condition. The village society, to be sure, cannot be asked to do this work; but the village society can see that it is done, or agitate effectively for it. The road laws in most States have recently been so amended that, wherever there is a public sentiment in favor of good roads, the State, or the county, or the township, as the case may be, has to make the needed improvements. Now, it should be the business of the village society to excite this public sentiment and so secure the roads. I have known this to be done in at least a dozen instances. Pressure can be brought to bear on the legislators, the selectmen, the freeholders, or whatever the officials may be called, which they will find it most difficult to resist. In this work women can be very useful, for men holding political positions feel that they can be rude to mere men who would reason with them, but they will have to listen to women out of courtesy, if nothing else; and the argument for good roads is so powerful that no man can really hear it and not be persuaded. In some States—notably in New Jersey—the freeholders cannot resist public sentiment as to road building. As, under certain conditions, the law is mandatory, they must make the improvements demanded.

When the roads have been put in good order, the question of sidewalks comes up. With good roads this is easy of settlement, for property owners are usually quite glad to make the proper kind of sidewalks themselves. But the society would do well to offer prizes for the best and greatest length of sidewalk constructed, and also to recommend a plan of walk, so that those in the village may be uniform. In some instances the society itself will have to do this work, but not often. When the sidewalks have become general, then the front fence question will come up. But by no means should any fences be taken down until the sidewalks have been made. When the

weather is bad and the walks are muddy, travelers will, if there is no fence, walk on the lawn and spoil it. This will give the advocates of fences another reason for holding out, and each of them, you may believe, will start out with reasons in plenty. If several leaders in the movement will, after the sidewalk building is finished, remove the fences in front of their places, they will furnish an object lesson more valuable than anything else. Then the matter will attend to itself. The next season other fences will come down, the third year still more; and in a little while a front fence will be so scarce as to be notable. But there is no way to force this destruction of fences. When Williamstown, Mass., was improved, many years ago, Mr. Cyrus W. Field offered to give to the society $10,000 when the last fence was taken down. At the end of eight years all the fences were gone save one. The owner of that held out for four years longer, and then reluctantly gave in rather than continue to remain in the Coventry to which his neighbors had sent him.

Another excellent thing to do in the very beginning of village improvement is to organize a league of school children. They should be instructed in tree planting for one thing, and in not littering the streets for another. Preparations should be made for a proper celebration of "Arbor Day," and on that day, with some appropriate ceremonies, trees should be planted where they are most needed. The children should be pledged not only not to throw paper into the streets, but to pick up all they see littering the ways.

I have not gone into some of the most important features of village improvement, because in each instance the problem is such that it must be discussed by itself. The making of roads will dispose of surface drainage. Sewerage, like water supply and lighting, must be attended to, and must be considered of great importance in the work of any village improvement society; but, for the reason stated, it cannot be discussed profitably on general lines. But I may say this, that a modern village, in which a modern spirit has been at work so effectively that the laws of health have been considered in the disposal of the sewage and the storage of water, is sure to be a better place both morally and physically, for vice is the handmaiden of disease. A village, however, should be even something more than moral and healthful; it should be beautiful, so that it may be worthy of the love that every home should inspire. These ends can be more easily accomplished through the work of a village improvement society than in any other way.—The Outlook.

[From the Astrophysical Journal.]

A SPECTROSCOPIC PROOF OF THE METEORIC CONSTITUTION OF SATURN'S RINGS.

By James E. Keeler.

The hypothesis that the rings of Saturn are composed of an immense multitude of comparatively small bodies, revolving around Saturn in circular orbits, has been firmly established since the publication of Maxwell's classical paper in 1859. The grounds on which the hypothesis is based are too well known to require special mention. All the observed phenomena of the rings are naturally and completely explained by it, and mathematical investigation shows that a solid or fluid ring could not exist under the circumstances in which the actual ring is placed.

I have recently obtained a spectroscopic proof of the meteoric constitution of the ring, which is of interest because it is the first direct proof of the correctness of the accepted hypothesis, and because it illustrates in a very beautiful manner (as I think) the fruitfulness of Doppler's principle, and the value of the spectroscope as an instrument for the measurement of celestial motions.

Since the relative velocities of different parts of the ring would be essentially different under the two hypotheses of rigid structure and meteoric constitution, it is possible to distinguish between these hypotheses by measuring the motion of different parts of the ring in the line of sight. The only difficulty is to find a method so delicate that the very small differences of velocity in question may be not masked by instrumental errors. Success in visual observations of the spectrum is hardly to be expected.

Soon after the large spectroscope of the Allegheny Observatory was completed, in 1893, I attempted to determine the relative motions of different parts of the system of Saturn, by photographing the spectrum with the slit parallel to the major axis of the ring, but failed to obtain satisfactory results. The unfavorable atmospheric conditions at Allegheny, the strong yellow color of the objective of the thirteen inch equatorial and the yellow color of Saturn itself so reduced the intensity of the violet part of the spectrum that the negatives obtained with a sufficiently high dispersion were too weak and granular to admit of measurement. Another unfavorable circumstance was the fact that I had to guide the practically invisible image corresponding to the $H\gamma$ line by means of the visual image, which was greatly out of focus on account of the chromatic aberration of the visually corrected telescope. Having recently obtained excellent results in other directions with orthochromatic plates, by the use of which the difficulties mentioned above are to a great extent obviated, I was induced to repeat my earlier attempts, and obtained two fine photographs of the lower spectrum of Saturn on April 9 and 10 of the present year. The exposure in each case was two hours, and the image of the planet was kept very accurately central on the slit plate. After exposure the spectrum of the moon was photographed on each side of the spectrum of Saturn, and nearly in contact with it. Each part of the lunar spectrum has a width of about one millimeter, which is also nearly the extreme width of the planetary spectrum. On both sides of the spectrum of the ball of the planet are the narrow spectra of the ansæ of the ring.

The length of the spectrum from b to D is 23 millimeters. The focus was adjusted on the line $\lambda 5352$, a little above the position of maximum sensitiveness of an orthochromatic plate, in the yellow green. On both plates the densities of the different spectra are very nearly equal, and the definition is excellent. It is hardly necessary to say that all the lenses used in the apparatus are visually corrected objectives.

These photographs not only show very clearly the relative displacement of the lines in the spectrum of the ring, due to the opposite motions of the ansæ, but exhibit another peculiarity, which is of special importance in connection with the subject of the present paper. The planetary lines are strongly inclined, in consequence of the rotation of the ball, but the lines in the spectra of the ansæ do not follow the direction of the lines in the central spectrum; they are nearly parallel to the lines of the comparison spectrum, and, in fact, as compared with the lines of the ball, have a slight tendency to incline in the opposite direction. Hence the outer ends of these lines are less displaced than the inner ends. Now it is evident that if the ring rotated as a whole the velocity of the outer edge would exceed that of the inner edge, and the lines of the ansæ would be inclined in the same direction as those of the ball of the planet. If, on the other hand, the ring is an aggregation of satellites revolving around Saturn, the velocity would be greatest at the inner edge, and the inclination of lines in the spectra of the ansæ would be reversed. The photographs are therefore a direct proof of the approximate correctness of the latter supposition.

To apply more precise reasoning to the subject under consideration, let us determine the form of a line in the spectrum of Saturn when the slit is in the major axis of the ring, on the assumption that the planet rotates as a solid body and the ring is a swarm of particles revolving in circular orbits according to Kepler's third law. At present the motion of the system as a whole is neglected. The upper part of Fig. 1 repre-

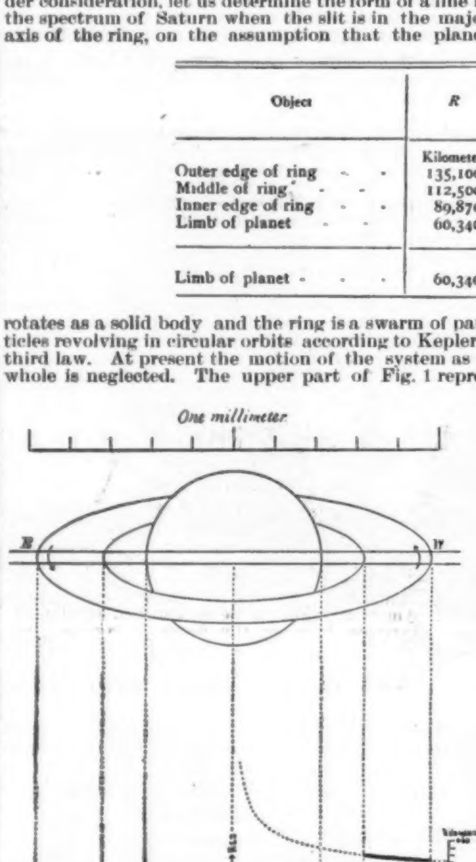


Fig. 1

sents the image of Saturn on the slit of the spectroscope (the scale above it applies to the instrument used at Allegheny), and the narrow horizontal line in the lower part of the figure represents an undisplaced line in the spectrum, or solar line.* Let this line be taken as the axis of x, and the perpendicular line through its center as the axis of y. The red end of the spectrum is supposed to be in the direction of the positive axis of y, and the camera and collimator of the spectroscope are assumed to have the same focal length, so that the breadth of the spectrum is equal to the length of the illuminated part of the slit. Corresponding points in the slit and spectral line will then have the same value of x. Now let x, y, be the coordinates of a point on the displaced line,

v = velocity of point corresponding to x, y in the line of sight,

V' = velocity of a point on the equator of Saturn,

α = angle between the line of sight and the radius of Saturn which passes through the point corresponding to x, y,

2ρ = width of spectrum,

β = elevation of earth (and sun) above the plane of the ring.†

The displacement y is proportional to the velocity in the line of sight. Then we have

$$x = \rho \sin \alpha,$$
$$y = av = aV' \sin \alpha \cos \beta,$$
$$\frac{y}{x} = \frac{aV'}{\rho} \cos \beta = \text{constant.}$$

Hence the planetary line is straight, but inclined to the solar line at an angle

$$\Phi = \tan^{-1} \frac{aV'}{\rho} \cos \beta.$$

* The curvature of the line in a prismatic spectrum need not be considered.

† The slight error introduced by the assumption that the earth and sun are in the same direction from Saturn is inappreciable when Saturn is anywhere near opposition.

To determine the form of a line in the spectrum of the ring, regarded as a collection of satellites, we have, by Kepler's third law,

$$T^2 = cR^3,$$

or, since $TV = 2\pi R$,

$$V^2 = \frac{4\pi^2}{cR}.$$

Since x is proportional to R and y to v (where v = velocity in the line of sight = V cos β) we may write

$$xy^2 = b,$$

which is the equation to the curve of which the lines in the spectrum of the ring are a part. The curve is represented by the dotted line in the figure; it is symmetrical with respect to the axis of x, but only the upper branch has a physical meaning, and the curve corresponding to the other half of the image is obtained by taking both x and y with negative values.

In the equation $V = \frac{k}{\sqrt{R}}$ log k = 3·7992 for the Saturnian system, R being expressed in kilometers and V in kilometers per second. The computed motions of different parts of the system are given in the following table. The gauze ring is not considered, as its spectrum does not appear on the photographs; the rings, A and B, are not separately distinguishable.

Object	*R*	Period of a Satellite at Distance *R*	Velocity	Velocity in Line of Sight April 10, 1895
	Kilometers	Hours	Kilometers	Kilometers
Outer edge of ring	135,100	13.77	17.14	16.35
Middle of ring	112,500	10.46	18.78	17.91
Inner edge of ring	89,870	7.47	21.01	20.04
Limb of planet	60,340	4.11	25.64	24.46
		Rotation		
Limb of planet	60,340	$10^h.23$ (A. Hall)	10.29	9.82

With the values given in the above table, and others which do not correspond to actual points in the system, the dotted curves were platted. For the ordinates, however, twice the values in the last column were taken, since the displacement of a line, due to motion in the line of sight, is doubled in a case of a body which shines by reflected and not by inherent light, provided (as in this case) the sun and the earth are in sensibly the same direction from the body. The planetary line is drawn to the same scale, and the heavy lines in the figure represent accurately the aspect of a line in the spectrum of Saturn, with the slit in the axis of the ring, as photographed with a spectroscope having about three times the dispersion of my own instrument.

The width of slit which I used (0·028 mm., or 7,900 km. on the surface of Saturn) is also represented in the figure.

If the whole system has a motion in the line of sight, the lines in the figure will be displaced toward the top or the bottom, as the case may be, but their relative positions will not be altered.

It is evident that in making a photograph of this kind the image must be kept very accurately in the same position on the slit plate, as otherwise the form of the lines shown in the figure would be lost by the superposition of points having different velocities. The second plate was made with special care, and as the air was steadier than on the first occasion, the definition is, on the whole, somewhat better than that of plate 1, although the difference is not great. On both plates the aspect of the spectrum is closely in accordance with that indicated by theory and represented in the figure. The planetary lines are inclined from 3° to 4°, and the lines in the spectra of the ansæ have the appearance already described. The slight curvature of the latter indicated by theory is, of course, unrecognizable. On account of the extreme narrowness of the spectra (barely more than a tenth of a millimeter), it was useless to attempt anything like a measurement of the inclination of the lines. The direction of such short lines is frequently masked by irregularities in the grain of the plate, and occasionally a line is considerably distorted. However, in fifty of the sharpest lines, in the region of best definition, only five were inclined in the same direction as the lines of the ball, while the rest were inclined as required by the theory or elsewhere apparently parallel to the undisplaced lines of the lunar spectrum.

If the ring revolved as a whole, the displacement of lines in its spectrum would follow the same law as for a rotating sphere; that is, the lines would be straight and inclined, their direction passing through the origin. If the ring rotated in the period of its mean radius, a glance at the figure shows that the lines would practically be continuations of the planetary lines. Such an aspect of the lines as this would be recognizable on my photographs at a glance.

It will be seen from the foregoing considerations that the photographs prove not only that the velocity of the inner edge of Saturn's ring exceeds the velocity of the outer edge, but that within the limits of error of the method the relative velocities at different parts are such as to satisfy Kepler's third law.

Besides (1) the proof of the meteoric constitution of the rings explained above, each line of the photographs gives (2) the period of rotation of the planet, (3) the mean period of the rings, (4) the motion of the whole system in the line of sight. I have measured a number of lines on each plate and compared the results with the computed values of the corresponding quantities.

The most acute method* of measuring the relative displacement of the opposite ends of a line in the spectrum of the planet is to measure the angle Φ.

The value of Φ depends upon the dispersion and other constants of the spectroscope employed, as well as upon quantities which are independent of the in-

* This method is due to Deslandres (C. R. 120, 417), and I have found it to be very satisfactory. The conclusions in Deslandres' article, with respect to the motion in the line of sight of bodies which are not self-luminous, are not new, although they are treated more fully than elsewhere.

strument. If we let L = the velocity of light in kilometers per second = 299,860; λ = the wave length of the measured line in tenth meters; D = the linear dispersion of the photographed spectrum at the position of the same line, expressed in tenth meters per millimeter; ρ = half the width of the spectrum in millimeters; we have by Doppler's principle, allowing for the double effect already mentioned,

$$y = x \tan \Phi = \frac{2v\lambda}{DL},$$

or,

$$v = x \tan \Phi \, D \frac{L}{2\lambda},$$

from which we obtain the velocity in the line of sight at the limb ($V' \cos \beta$) by placing $x = \rho$. That is,

$$V' = \frac{\rho DL \tan \Phi}{2\lambda \cos \beta}.$$

The value of ρ is computed from the angular semidiameter of the planet and the focal length of the telescope. It cannot be obtained accurately by measurement of the photograph, because the borders of the spectrum are indistinct. For my instrument at the time of observation, ρ = 0·2134 mm. D is obtained from a wave length curve constructed from measurements of a standard plate of the solar spectrum made with the same apparatus, and Φ is directly measured under a microscope provided with a position circle.

The relative displacement of a line in the spectra of the ansæ is measured directly, the micrometer wire having first been placed parallel to the lines of the comparison spectrum. If δ is this measured interval, the mean velocity of the ring is

$$V'' = \frac{DL\delta}{4\lambda \cos \beta}.$$

The displacement could also be determined by measuring the angle which the line joining the centers of the two short lines of the ansæ makes with the comparison lines. I have found the direct method to be preferable.

There remains the motion of the whole system in the line of sight, which has hitherto not been considered. It is best determined by comparing the mean of the positions of the lines in the spectra of the ansæ with the corresponding line of the comparison spectrum. The results for this motion are unsatisfactory, as might be expected from the circumstances of observation. Owing to the fall of temperature during the rather long exposure of two hours, and the fact that the lunar spectrum was photographed at the end, and not in the middle of the exposure to the planet, the two spectra are relatively displaced by an amount which is about ten kilometers greater than that due to the motion of Saturn in the line of sight. I have therefore made no careful measurements of this displacement. For the reasons given above, the planetary lines are somewhat less sharp than the lines in the lunar spectrum, which was photographed with an exposure of only six minutes.

The results of all the measurements are given in the following tables:

PHOTOGRAPH NO. 1, APRIL 9, 1895.

λ	D'	Φ	Velocity of Limb	$C-O$	δ	Mean Velocity of Ring	$C-O$
Tenth-meters	Tenth-meters	° ′	Kilometers	Kilometers	Millimeters	Kilometers	Kilometers
5324.3	27.55	3 36	10.92	−0.63	0.0456	18.54	+0.24
5328.4	27.65	4 24	13.39	−3.10	0.0464	18.92	−0.14
5371.6	28.77	3 11	9.99	+0.30	0.0404	17.01	+1.77
5383.5	29.09	3 20	10.56	−0.27	0.0362	15.37	+3.41
5429.9	30.37	3 8	10.27	+0.02	0.0402	17.67	+1.11
			11.03	−0.74		17.50	+1.28

PHOTOGRAPH NO 2. APRIL 10, 1895.

λ	D	Φ	Velocity of Limb	$C-O$	δ	Mean Velocity of Ring	$C-O$
Tenth-meters	Tenth-meters	° ′	Kilometers	Kilometers	Millimeters	Kilometers	Kilometers
5324.3	27.55	2 11	6.62	+3.67	0.0468	19.03	−0.25
5328.4	27.65	3 19	10.09	+0.20	0.0412	16.81	+1.97
5371.6	28.77	2 42	8.47	+1.82	0.0436	18.35	+0.43
5383.5	29.09	3 13	10.19	+0.10	0.0420	17.84	+0.94
5429.9	30.37	3 49	12.51	−2.22	0.0468	20.56	−1.78
			9.58	+0.71		18.52	+0.26

The results from both photographs are

Velocity of limb = 10·3 ± 0·4 kilometer,
Mean velocity of ring = 18·0 ± 0·3 kilometer;

the computed values being 10·29 and 18·78 kilometers respectively.

Although there seems to be no systematic difference between the two plates, the results for each differ by more than the probable error. With photographs on so small a scale, distortions of the lines are produced by the irregular deposit of even a few particles of silver; hence it is advisable to measure a large number of lines instead of multiplying observations on a few of them.

The number of lines in the table is, however, sufficient for the present purpose.

As I have already pointed out, it is necessary to guide the telescope with extreme accuracy in making such photographs as those described in the present paper, and the method which I have used is so simple and effective that a short account of it may be of interest.

The spectroscope is fully described in Astronomy and Astro-Physics, 12, 40, January, 1893, and the prism train used in these observations is there shown in plate VII. The slit is observed during an exposure by a small "broken" telescope, which receives the rays reflected from the first surface of the prism nearest to the collimator.

To prepare for an observation of Saturn, the slit is shortened until its length is equal to the computed length of the image (major axis of the ring). A small bar, which is wider at one end than at the other, is cut out of thin metal, and placed across the field of the diagonal telescope. If the bar is approximately of the right width, then, by throwing the image of the slit a little above or below the center, and by rotating the eyepiece, which carries the bar with it, the bar can be made to very nearly cover the image, leaving a very short length of slit uncovered at each end. When the telescope is directed to Saturn the extreme ends of the ring appear from behind the (invisible) bar as two minute points or stars, and the attention of the observer is concentrated on keeping these stars equally bright. Any displacement in declination is indicated by their disappearance or unusual faintness. The photographs show that the guiding by this method is quite accurate. The spectra of the ansæ do not show any traces of the Cassini division, but it would probably be requiring too much to expect that they should do so, considering the small size of the image and the length of the exposure.

It is a question whether these observations could be better made with a larger telescope. If the same spectroscope were mounted on a large telescope, the width of the photographed spectrum would be greater, the lines would be longer, and their direction could be more definitely measured. On the other hand, the inclination of the lines would be diminished, since tan Φ varies inversely with ρ, and it could not be increased by employing a greater dispersion, as the brightness of the spectrum, which would be the same for both telescopes, would hardly bear any further reduction. A material advantage would be that with the same slit width a smaller area of the image would be included between the jaws, and hence at any part of the slit there would be fewer points having different velocities in the line of sight. On the whole, it seems to me that the advantage would lie with the large telescope. With a reflector, or a photographically corrected refractor, the photographs could be taken at the Hγ line, where the dispersion is more than twice as great as in the region near λ 5350, and the only difficulty in that case would be found in the yellow color of Saturn.

I have given a somewhat full account of these observations, partly because of the interest inherent in everything that relates to the magnificent system of Saturn and partly because the successful application of the spectroscope to the measurement of celestial motions depends largely upon details of appliances and methods.

NOTES ON YUCATAN.

THE expedition sent out in January, by the University of Pennsylvania, had for its object the discovery of culture layers in the caverns of Yucatan. It was thought that proof of man's antiquity in this part of Central America ought to be established by the discovery of refuse beds on the floors of conspicuous, easily accessible caves, and a group of these shelters, situated in a mountain range, midway between many of the ruined cities, were chosen for exploration, as probably containing evidences of every race that ever visited the peninsula.

When these cave floors were cut down to bed rock, and when the surface stratum of Maya occupation was sliced through, the work was expected to decide whether other earlier epoch-made refuse beds were to be encountered before the trenches reached rock bottom. This was the main question of the expedition, and the investigation which has, in a great degree, settled it remains to be described in the report presently to be published by the University of Pennsylvania.

The thanks of the University are due Mr. John W. Corwith, of Chicago, for placing his time and means at their disposal in the undertaking. No less should acknowledgment be made to Dr. S. Weir Mitchell for advice and assistance in the outfit. Important co-operative aid has been furnished by Dr. William Pepper, President of the Association, by Dr. D. G. Brinton and Professor E. D. Cope; while the expedition owes its choice of the Sierra de Yucatan to the geographical help given it by Professor Angelo Heilprin, of the Academy of Natural Sciences, of Philadelphia.

Certain notes, taken upon the journey, and not bearing directly upon the results of the work, may interest students. They recall an interesting conversation at Ticul, in February, with Herr Maler, the archæologist, who, coming to Mexico with the French expedition, has remained in Yucatan as a student of its antiquities, ever since.

Nothing, next to the stone work of the ruins themselves, so strikes the explorer in the peninsula as the remarkable predominance of pottery over all other relics of human handiwork. Herr Maler believes that much of the craft of the old earthenware might be relearned and recovered by a study of the work of the present Indian potters. Some of the pots were, he supposed, baked over the constricted calabash, now used as a water bottle, but on none were noticed traces of the potter's wheel. Pottery is found everywhere, but no hunting grounds have proved so rich as the Chultun, artificial, clock-shaped cisterns, built by the ancient Mayas, for catching rain water. He who is staggered at the task of searching for sights of habitation in the stony, thorny, insect-haunted jungles, saves labor by climbing down into these round holes, so often seen in the woods and near mounds, now dry inside. When not repaired for modern use, their plastered floors generally contain two or more feet of rubbish, whence come many of the perfect vases, cups and jars which leave Yucatan. Chief among these is the wide-necked water jar, miniature models of which are sometimes found in the debris; the latter being probably playthings dropped by children into the cistern, and there lost beyond easy recovery in the deep water.

But the ruins themselves, by all means the most conspicuous relics of the past in Yucatan, visited and studied, perhaps, to exclusion of almost everything else, suggest a puzzling question which yet defies answer: How were the stones cut which surprise us by the richness of their ornament? Were the tools used random masses of similar material—chips of the old block, lavishly used to cut the parent stone? Were they the pitted hammer stones of Mr. McGuire's theory, or chisels made of harder rock? Were they implements of copper? Whatever any or all of them were, none of them have been discovered in such a position as to prove their use. Yet, so immense is the amount of the Maya stone work, that the wonder increases as we think of it, and we fancy that the kind of tool we search for, battered and cast away, or well worn on its cutting edge, should be scattered about the ruins thicker than potsherds. The only reasonable explanation why not one single such tool has ever been found is Herr Maler's—that the country is too much overgrown with thicket, too much obscured by uncultivatible stone heaps to make it easy to find anything.

Stone quarries near certain of the ruins where the native limestone had evidently been blocked out for building had been noticed by Herr Maler, and, though a modern quarryman rarely loses tools at the quarry, it is fair to suppose that a careful and prolonged search among the chips at these places might disclose one or two specimens, at least, broken or whole, of the cutting tool sought for. If the implements used were stone, the chance of finding a fragment, at least, is increased, since breakage would have disqualified many specimens for the work. While much stone chipping was undoubtedly done at the ruins, during building, and while there are probably stonecutters' workshops undiscovered close by the crumbling walls of Uxmal or Labna, it seems that an overhauling of these isolated quarries in the woods would easiest settle the vexed question.

Herr Maler had found no traces of earlier peoples in Yucatan, such as in Asia and Europe meet the explorer at every turn. If a more ancient race of builders had preceded the Mayas, then the latter would have used again previously cut stones in their houses. But they did not; all the evidence showing that they originally dressed their building stone from native rock. That the builders of the ruins lived chiefly on maize, beans, roots, melons and fruit he had little doubt. Flesh they rarely ate, and had no domestic animals except the dog. Of these he believed that there had been several indigenous kinds—one hairless, much used for food by the early Spanish explorers, existing still in Mexico, but now extinct in Yucatan. Another breed, he supposed was humpbacked, as is indicated by humpbacked figures of dogs, carved on the sixteenth century facade of Governor Montillo's house in Merida.

The explorer has not yet found much to astonish him in the graves of the ancient Mayas. Herr Maler says they lie thick near most mounds, rudely outlined with small rectangles of stone rather than indicated by earth heaps, so there is no way of discovering them when these little rows of stone become scattered, as is now generally the case, save at undisturbed spots in the remote wilds. Under them, skeletons, much decomposed, lie about three feet deep, sometimes in boxes of undressed slabs, after the manner of the stone graves of Tennessee, but oftener in the open earth. If valuable trinkets of jadeite or nephrite and vases painted with hieroglyphs are not to be found in these tombs, we should hardly know where to look for them. But Herr Maler says that few graves reward search. Of hieroglyphs on vases he had seen several specimens, and showed me one such incised inscription at his house.

The mounds do not repay the explorer as they seem to promise. Instead of containing some tomb altar or inclosed chamber at their very center, digging proves many of them to be heaps of loose bowlders piled up for the purpose of erecting vaulted chambers on their sides and top. These ill-constructed structures have generally crumbled piecemeal into a loose talus that now forms the sides of the mounds, and the tumuli have become round, bramble-covered rubbish heaps, haunted by scorpions and garapatas. As a rule, with few exceptions, there are no graves inside the typical mound, which contains three tiers or steps of the buildings in question, each with its plastered terrace. In the debris of the old floors of these rooms many interesting fragments of pottery, sometimes showing religious symbolism, sometimes imitating the forms of birds, monkeys and jaguars, have been found.

Of monkeys, Herr Maler believes that there are two or three species in Yucatan. One small earthen monkey head, which he showed me, was truer to nature and less grotesque than other miniature human busts in his collection. Of these latter, one hideous face had been presented to him by a Maya sorcerer at Bolon Chen, as a charm of great value. Obsidian

flakes and flint knives, such as he showed me, were rare, since the modern Indians who found them soon broke or lost them. The flint, of a creamy white color, he had often found in the native state in swamps. Several earthen cloth stamps showed interesting curved designs, and two earthen whistles blew loud enough to have pleased a boatswain. Strange to say, he had but one arrowhead, but showed me several polished celts, probably of syenite or jadeite, from Chichen-Itza, Cozumel, and other places. They were somewhat worn on the cutting edges, but, in my opinion, could not have been used to carve limestone.

Much light might be thrown on the history of the old inhabitants of Yucatan by a study of the modern Mayas, but Herr Maler supposed that the demonic beliefs and practices of the mystic brotherhood, known to students as Naguales, had faded away among the docile people of eastern Yucatan. The word Nagua, a familiar spirit in animal forms, is not used among them; nevertheless, I suspect that interesting results would reward the investigator of this subject who first mastered the language and then gained the confidence of these people. — H. C. Mercer, American Naturalist.

ORIZABA.

AMERICAN travelers on their way to the city of Mexico via Vera Cruz should ask for the ticket "con privilegio de intermission a Cordova"—"stop-over privilege at Cordova"—in the foothills of the most picturesque mountain of the western hemisphere. Cordova is a railway town, with the usual medley of Mexican taverns and Yankee restaurants, and without special local attractions, except the shops of the pet dealers, who sell all sorts of zoological curiosities, from a monkey to an American chameleon. In June the coffee tree groves south of the little town fill the air with their pungent perfumes and may reward butterfly collectors for a few hours' ramble in quest of tropical novelties; but lovers of picturesque scenery will make straight for the valley in the northwest. No guide is needed. Mexican stock farmers dispense with fences and the hillside pastures afford free access to the park-like chaparral of buckthorns and evergreen oaks near the summit of the ridge. The last 200 yards of the ascent are pretty steep, but the view from the top abundantly repays the climber's toil.

A deep gorge skirts the northern slope of the ridge and beyond its north side cliffs, range above range of wooded mountains, ascend like the terrace of a Titan's castle toward the tower peak of Mount Orizaba, the grandest American rival of the Matterhorn. Up to a height of 12,500 feet the flanks of the great volcano are densely wooded; then comes a tower base of rocks and basaltic debris with a streak of meadow land here and there; but the upper 500 feet form a perfect cone from every point of vision and the dazzling gleam of the snow fields can be seen far out at sea and may have suggested the Aztec name of the Citlaltetpl, or Star Mountain.

And that magnificent peak is in all probability the highest mountain of the North American continent. The claims of one of its supposed rivals, Mount St. Elias, were exploded four years ago, and those of the volcano of Popocatapetl became doubtful when Major Favre's surveys demonstrated the fact that the altitude of the central tableland has been considerably overrated. The Spanish geographers made the height of Mount Orizaba 17,500 feet and that of Popocatapetl 17,750, founding the latter estimate on the belief that the plane of Anahua, near the city of Mexico, had an average elevation of 8,000 feet, which would have to be added to that of the volcano above the base of its foothills.

But as early as 1866 French surveyors called attention to the circumstance that the snow cone of Orizaba rises about 300 feet above the limit of the arboreal vegetation, and that the summit plateau of central Mexico is considerably depressed in the vicinity of the capital; so much so, indeed, that the drainage of the higher levels collects here in the basin of three good-sized lakes, without an outlet. Major Favre, after a careful survey of the mountain chain that divides the plateau of Cuebla from that of Anahua, reduces the average height of the latter from 8,000 to 7,600 feet, and if we shall accept that conclusion, Mount Orizaba can claim an altitude of at least 100 feet in excess of its only possible competitor.

South America, of course, can boast of several higher mountains, but all of them have for a pedestal the lofty plateau of the central Andes, reducing their apparent height some 10,000 feet, while Orizaba rises directly from the hills of the coast range, and from numerous points of view can thus be seen in all the majesty of its actual height above the level of the ocean. The Matterhorn is a trifle steeper, and as seen from the hills of Zermatt looks indeed as inaccessible as a mountain of the moon, the tremendous east side precipice being an almost perpendicular ice tower of 3,000 or 4,000 feet, but the culminating point of the peak is only about 14,000 feet above the Mediterranean and that of Mount Kasbek, in the Caucasus, about 14,300 feet. Misshapen Mont Blanc, too, is 2,000 feet lower than Orizaba, and has the further disadvantage of being hemmed in by broad tablelands, preventing the simultaneous view of the summit and the seaward slope of its hills. The distance of Val Chamouni from the nearest seacoast, say Genoa, is about 220 English miles, while opposite the foothills of Mount Orizaba the Gulf approaches the great coast range within forty miles.

Sailors skirting the coast of Mexico between Tampico and Vera Cruz see the top of the Star Mountain like a glittering white pyramid above the blue haze of the western horizon, and it is a pity that Cristoval Columbus, that noble lover of grand scenery, so narrowly missed two good chances for getting a glimpse of the great peak. By keeping his original course due west from the Azores he would have reached the coast of Mexico or of Florida, but on the morning of Oct. 7, Pinzon persuaded him to steer southwest, where he declared a foreboding assured him of the neighborhood of land ("el-corazon me da," "my heart tells me," as he expressed it). But change of direction resulted in the discovery of the Bahamas, and again, two years after, a council of his pilots shifted his course toward Venezuela, instead of keeping west, along the parallels of San Domingo. Pedro Robledo, a follower of Cortez who came in sight of the peak on a reconnoitering trip, described it as the "marvel of the New World," a "prodigy unrevealed to the great admiral," Columbus, who, indeed, never saw a higher mountain than the peak of Santander, in northern Cuba, about 9,000 feet high, and which he pronounced the highest summit of the land that ought to have been called after his name.

I ascended the peak from the neighborhood of Fort Perote in the summer of 1867, and still remember the delight of my traveling companion at the parklike appearance of the terraces, where cliffs of fantastic shape alternate with grassy glades, groves of larch trees and patches of strawberries and flowering rhododendrons, far along a crest of a ridge that would afford playgrounds for the school children and tourists of all the nations between St. Petersburg and San Francisco. The fauna of these highland regions resembles that of our Southern Alleghanies. Blacktail deer and rabbits prefer the fine grass and aromatic mountain herbs to the rank vegetation of the lower valleys; the ravines are haunted by a long-legged variety of mountain grouse that rely on their pedestrian abilities and rarely take wing at the hunter's approach. Black and gray squirrels divide the larch nuts with a little bird of the crossbill kind. From the top of an overhanging cliff, where we rested a few minutes, our guide started a big bowlder and sent it bounding toward the foothills, but a projecting rock deflected it to the right into a little grove of holm oaks we had passed about ten minutes before. Not the bowlder, but a troop of blacktail deer emerged from the trees and went through the juniper bushes and round the corner like a whirlwind. As the grove did not contain more than a few dozen trees, we must have passed close to the troop, and if they did not see us, they certainly must have heard us talk, yet they did not think it worth while to interrupt their matinee on our account.

We had to made a considerable detour to reach the ridge that connects the volcano with the main chain of the Sierra, for the western slope of the peak is dreadfully steep, and we were unprovided with mountaineering gear—ropes, claw shoes, and ice axes.

As we approached the ridge the rock chaos became intricate and obstructive, but the grade was not very steep here, and at about 10 A. M. we reached the divide and beheld now, for the first time, the eastern slope of the North American continent. The average height of the Sierra Madre surpasses that of the western Alps by more than 6,000 feet, and the greater elevation of the snow line makes the highlands far more accessible, but the view from the summit of the Mexican Cordilleras owes its peculiar grandeur to the wonderful transparency of the air. Nowhere else on earth is the atmosphere at the same time so humid and so free from consolidated clouds; the radiation of heat from the elevated table lands seems to transfigure all gaseous moisture into an aerial vapor that re-enforces the light it transmits and endows the eyes with a strange telescopic power. That haze of the horizon which limits the vistas from an Alpine height veiled the swamp coast of Yucatan, but in the north, the east, and the northwest, the view was bounded only by the incurvation of the globe, and the outlines of the peak of Sirenas in the state of Oaxaca appeared as sharp and distinct as those of a jagged cliff at our feet. The bay of Vera Cruz is visible, with all its harbors and white beaches; the flag on the citadel of San Juan de Ulloa appears and disappears as the sea breeze moves it; the ruins of Fort Antigua, where Cortez effected his first landing, can be plainly distinguished above the trees of the coast swamps, and where water and sky meet in the northeast, the lighthouse on the island of Bermejo glitters like a rising star. At our feet we saw the terrace land of Vera Cruz, a vast chaos of gray rocks and somber pines, rising above the undulating foothills with their tarnes and pleasant groves; further down the table land, intersected by deep ravines and dotted with settlements here and there, and below all that the tierra caliente, with its evergreen forests that stretch away to the north and southeast as far as the eye can reach and border the land with a frame of eternal summer.

The last thousand steps of the ascent to the brink of the crater were uphill work in the deepest sense of the word, and it was near noon when we reached the last barricade of jagged crags, helped each other up, and stood upon the apex of the North American continent.

"Oh, mis rodillas—my knees! my knees!" laughed our guide, as he threw himself upon the loose rocks. "I could not go up another slope like that if I knew it was leading straight into heaven."

"Take care, amigo," said my traveling companion, "or you might happen to land in the other place; you are sliding right toward the trapdoor of it."—The Philadelphia Times.

THE BENIER GASOGENE MOTOR.

IN L'Energie Electrique there is an article by Prof. Amie Witz, of Lille, upon some tests which he has made of a Benier gasogene motor. The motor is a two cycle one, drawing its gas from the producer by aspiration, without gasholder or scrubber; it has one explosion per revolution, thanks to the use of two cylinders, one a compression cylinder, the other the motor cylinder; the axis of these being parallel and the cranks arranged at right angles. The nominal power of the machine tested was 15 horse power at 150 revolutions. The gas producer was big enough for a 25 horse power motor, but this proved useful, for it enabled comparative tests to be made with coke and anthracite. The space occupied by the whole affair was 17 ft. 3 in. by 5 ft. 4 in. floor by 6 ft. 8 in. height. The anthracite was from England, good, sifted; heating value about 14,400 (in British units). The coke was Paris gas coke, with about 10 per cent. of ash and $6\frac{1}{4}$ per cent. of moisture; heating value about 12,240 units. Anthracite reckoned at 28s. a ton and coke at 22s. 5d. In a twelve hours' run with anthracite the effective power was found to be 14·59 horse. The net consumption of anthracite was, in the twelve hours, 125 kilog. ($2\frac{1}{2}$ cwt.); water, 22,000 gallons; percentage of heating value utilized, 11·3. With coke: Horse power, 14·5; coke, 115 kilog. (say 2·3 cwt.); heating value utilized, 12·4 per cent. In the gas producer the firebars are hollow; a current of water goes through them and is converted into the required steam at low pressure. There was no need, with anthracite, to rake the bars during the twelve hours, and the action was regular and very silent. Prof. Witz concludes: "We have here, then, a producer motor occupying a space only a little more than 10 square yards, which may be placed anywhere without fear of poisonous gas, since the working of the producer by aspiration renders all escape of gas impossible; which only uses 0·192d. worth of a fuel which can be obtained anywhere, and 125 gallons of water per effective horse power per hour."—Gas World.

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